# DoD Cooperative R&D Agreements:
## Value Added to the Mission


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BOOZ·ALLEN & HAMILTON
Arlington, VA

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# Executive Summary

Some trends have been emerging over the last several years that significantly effect the way the Department of Defense (DoD) conducts R&D. One trend is the fact that budgets for R&D (in real dollars) will continue to decrease. Also, the development of commercial high tech industries will continue to be a source of innovation for military procurements in some industrial sectors. With the shrinking of the Federal R&D budget and the proliferation of technology, federal laboratories need to find alternative ways to leverage their R&D through alliances with industry.[1] Industry also prefers to leverage their own R&D efforts by exchanging ideas, accessing unique facilities, and building on the work the labs have done.[2]

The purpose of technology transfer is to make federally generated scientific and technological developments accessible to private industry and the state and local governments. Legislation has focused on the transfer of technology from the Federal laboratories to the private sector, however, value also has been realized by the federal partners. The Cooperative Research and Development Agreement (CRADA) is one mechanism by which technology transfer can occur. The CRADA is a mechanism which allows flexibility in R&D and protects the intellectual property of both parties. The objective of this study was to evaluate a sampling of DoD CRADAs to assess the benefits that the DoD is reaping from participating in these agreements.

The intent of Congress has remained essentially the same for many years: leveraging federal R&D dollars for the greater good of the economy. The expectation has been that more partnerships between industry and Federal labs would improve U.S. competitiveness, help small businesses, and create new jobs and products for the nation's economy (The Stevenson-Wydler Technology Innovation Act of 1980 and the Technology Transfer Act (TTA) of 1986). In accordance with these laws, the FY93 Defense Authorization Act established the Office of Technology Transition within the Office of the Secretary of Defense to ensure "that technology developed for national security purposes is integrated into the private sector of the United States in order to enhance the national technology and industrial base, reinvestment, and conversion activities...."[3] As illustrated in a Secretary of Defense memorandum, the OSD is clearly encouraging technology transition activities to promote cost sharing of DoD R&D through dual-use initiatives; integration of commercial technology through "spin-on" mechanisms, as well as making existing technology more affordable and accessible through spin-offs.[4]

As of the time of this study, June 1998, there were a total of 2456 DoD CRADAs initiated since the inception of the TTA of 1986. Of the 2456 CRADAs, 1256 were completed or closed-out. Initially the study was to focus exclusively on closed CRADAs, however, difficulties were encountered in finding federal POCs who had either retired, left the Government, or whose positions were eliminated as a result of base closures and also in finding non-federal POCs whose companies no longer existed. Therefore, it was determined that the most practical approach was to focus on CRADAs that were closed as well as some that were still open and already showing progress. CRADAs were selected from those that were available and recommended by the Offices of Research and Technology Applications (ORTAs) as well as from those that were gathered from various published sources. This study was not meant to be comprehensive. Since it was not practical to evaluate all CRADAs, a sampling of 30 CRADAs were chosen (10 from each Service) for evaluation from a total of 131 CRADAs that were identified for possible use in this study.

DoD has developed five management principles to guide in the development of the S&T programs of the Military Departments and Defense Agencies. These management principles, or elements, are designed to place the best mix of capabilities possible into the hands of the operational forces by leveraging the best resources in the DoD and the nation.[5]

*Guiding Management Principles of the DoD S&T Program*

- Transition Technology to Address Warfighting Needs
- Reduce Cost
- Strengthen the Industrial Base
- Promote Basic Research
- Assure Quality

## Army CRADAs

| | | Address Warfighting Needs | Reduce Cost | Strengthen the Industrial Base | Promote Basic Research | Assure Quality |
|---|---|---|---|---|---|---|
| A1 | Advanced Technology for High Resolution Physics Based Interactive Simulations | ● | ● | | ● | ● |
| A2 | Blanket CRADA Between Ford, General Motors, Chrysler and the U.S. Army Tank-Automotive Research, Development and Engineering Group | | | | ● | |
| A3 | Construction Equipment Performance Optimization | | | ● | ● | ● |
| A4 | CORE-LOC Concrete Armor Unit | | | ● | ● | |
| A5 | Development of Biodegradable Polymers | | | ● | ● | |
| A6 | Development of Novel Imaging System for Medical, Non-Destructive Testing & Investigation of Micro-electronic Circuits | | | ● | ● | |
| A7 | Evaluation of Electron Cyclotron Resonance Plasma Technology | ● | | ● | ● | ● |
| A8 | Formulation of a Liposomal Transdermal Vaccine System and Other Novel Pharmaceuticals | ● | | ● | ● | ● |
| A9 | Full Scale Fabrication & Optimization of Composite Cylinder Processing | | ● | ● | ● | |
| A10 | Vaccines for Infectious Desease | ● | | ● | | ● |

## Navy CRADAs

| | | Address Warfighting Needs | Reduce Cost | Strengthen the Industrial Base | Promote Basic Research | Assure Quality |
|---|---|---|---|---|---|---|
| N1 | CRADA between The Naval Training System Center and Computer Group of Motorola, Inc. | ● | ● | | ● | |
| N2 | Deep-Towed Acoustic/Geophysical System | ● | | | ● | |
| N3 | Demonstration of CL-20 Based Explosive Formulations | ● | | ● | | |
| N4 | Detection of Contraband and Narcotics by Nuclear Quadrupole Resonance (NQR)/Fast Recovery Time Nuclear Quadrupole Resonance Detection | | | ● | ● | |
| N5 | Electric Vehicle/Hybrid Electric Vehicle Battery Chemistry Research & Evaluation | | | | ● | |
| N6 | Exploring the Effects of Lipid-Lowering Agents on Complex Cognitive and Performance Tests | ● | | | | |
| N7 | New Paint Formulations for Fluorinated Polyurethane Resins | | ● | ● | | |
| N8 | Ocean Bottom Profiler (OBP) Joint Project | ● | | ● | ● | |
| N9 | Technical Assistance to CIT | | | ● | ● | |
| N10 | Use of Spinning Microfilters to Separate Oil from Water for Abatement of Marine Spills | | | | ● | |

## Air Force CRADAs

| | | Address Warfighting Needs | Reduce Cost | Strengthen the Industrial Base | Promote Basic Research | Assure Quality |
|---|---|---|---|---|---|---|
| AF1 | Automated Software for Composite Material Analysis | | | ● | ● | |
| AF2 | Covert Adjustable Laser Illumination CRADA | ● | | ● | | ● |
| AF3 | Hazardous Materials Management System | | ● | ● | | |
| AF4 | Helmet Mounted Display Fitness of Use | ● | | | ● | |
| AF5 | Ogden Air Logistics Center X-Ray/Computed Topography Sections | | | ● | ● | |
| AF6 | Strategic Avionics Battle Management Evaluation and Research (SABER) | ● | ● | | | |
| AF7 | Test and Evaluation of Imaging System | ● | | ● | | |
| AF8 | USAF CRDA Between Weber State University and the Science and Engineering Laboratory | | | | ● | |
| AF9 | Warhead Arena Test | | | | ● | |
| AF10 | Whole Spacecraft Isolation System for Taurus/GEOSAT | ● | ● | | ● | |

Given that there is no common definition of "value" (i.e. metrics) as it relates to a CRADA, the DoD S&T guiding management principles were used as a means of showing value back to DoD. CRADAs must support specific R&D efforts that are related to and consistent with the DoD laboratory's mission, therefore, it is reasonable to assume that if the CRADAs evaluated in this study reflect the DoD S&T management principles, then they add value to the DoD S&T program as a whole. In fact, many of the CRADAs evaluated in this study met more than one of these management principles.

Many interesting findings were deduced from the information gathered from the interviews with the federal and non-federal CRADA partners on their particular collaborations. There is a belief that CRADAs should lead to commercial products in order to be considered "successful." However, in actuality this appears to be the exception rather than the rule. CRADAs typically entail knowledge-share opportunities that facilitate advances in research leading to product or process improvements, advancing research to points that would have taken longer to achieve independently, or allowing an opportunity to perform research that would not have otherwise occurred due to restricted funding resources. The following findings were recurring themes described by participants in the collaborations.

*General Findings*

- CRADAs are seen by many Labs as mission extenders
- CRADAs can provide a means for industry to talk openly with Government
- CRADAs are a means of advancing research to points that would otherwise have taken longer to achieve independently
- CRADAs can provide access to Government/Military facilities that are not otherwise commercially available
- CRADAs can result in new, improved, or more cost effective products/processes
- CRADAs can eliminate interpersonal barriers that can arise in a contractual relationship
- CRADAs are successful when objectives are clearly laid out
- CRADAs can advance research for both partners sometimes leading to new programs/contracts
- CRADAs that result in follow-on CRADAs between organizations is an indicator of progress

In supporting the belief that successful CRADAs should lead to commercial products, many of the CRADAs selected for evaluation in this study resulted in products or product improvements. Some of the products are either still in development or pending commercialization, however, they are at stages where they are considered to be viable products. In some cases, the use of DoD facilities or test sites provided a means for products to be further refined as a result of the data gathered by the industry partner.

The values for both the work-in-kind and cash-in (cash-in was $31,046,098.00 in FY98) illustrate the importance industry is associating with the CRADA mechanism as well as the significant contribution partnering is making to the DoD mission. The actual dollars that are coming into the laboratories cover such costs as overhead, materials, third party contracts, and travel expenses.

In addition to the above findings, during the course of the study some interesting insights were discovered. In most cases, the ORTA is not the first point of entry for an industrial partner wishing to do business with the DoD. CRADAs are typically initiated through working relationships that have evolved between scientists over the years through research conferences, consortia, contracts, etc. In some cases the industrial partner or government scientist initiates a literature search to find those people working in a specific area of interest. This finding underscores the need for S&Es to know how to use this mechanism.

It was interesting to note that the scientists and engineers are not as aware as they should be of the technology transfer process that exists at their laboratories. Additional training in technology transfer processes and what the mechanisms can do for the S&E could exploit the use of these mechanisms making technology transfer more effective.

In reviewing the sample of CRADAs selected, it became apparent that these collaborations do not take a simple linear route to commercialization and may only serve as one step in a series of steps along the route. Each partnership is unique in its process to meet its objectives. Some CRADA partnerships are a continuation of an earlier contractual partnership for the purposes of bringing a technology into the commercial sector. Some CRADAs lead to a patentable product or process bringing dollars back to the laboratory. Some CRADAs leverage R&D dollars and make small advances in a specific technological area which over time (and maybe many CRADAs later), may lead to a product or process which the DoD can access.

Three exemplary CRADAs, one from each Service, are showcased in detail to illustrate their value to the DoD mission and to the private sector.

*Three Exemplary CRADAs*

- Evaluation of Electron Cyclotron Resonance Plasma Technology
  - Partners: CECOM/NVESD and Texas Instruments
  - Accomplishment: Manufacturing improvements for higher density focal plane arrays. Used new etching process to produce an array 128 pixels X 128 pixels.
  - Impact: One of DoD's long-term investment initiatives in technology maturation
- CRADA Between Naval Training Systems Center and the Computer Group of Motorola, Inc.
  - Partners: NAWC and Motorola
  - Accomplishment: Gained experience in working with new interoperability standard. Co-developed three DIS software tools (Middleman, Aladdin and Daemon)
  - Impact: Tools are used to connect simulators of complex battlefield scenarios
- Hazardous Materials Management System
  - Partners: Air Force Research Laboratory and Modern Technologies Corporation
  - Accomplishment: Beta tested the LINDEN™ Environmental Management System for hazardous materials management.
  - Impact: Streamlined hazardous waste management operations. Winner of the 1995 Ohio Governor's Award for Outstanding Achievement in Pollution Prevention

In summary, in times of constrained R&D budgets, whether it be a small business, a large business or a DoD laboratory, the public and the private sector can benefit from leveraging expertise that lies outside of their own labs in areas of mutual interest. It is evident from this study, that the CRADA mechanism is the mechanism of choice for accomplishing these partnerships. Drawing upon external expertise can provide the means to overcome obstacles that arise along the path to new discoveries or even determine that the path being pursued is leading to a dead-end and another needs to be followed. New knowledge can lead to advancing the research to the next level in the development cycle or can spawn new ideas leading to new R&D programs altogether.

# Acknowledgements

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# I. Introduction

Some trends have been emerging over the last several years that significantly effect the way the Department of Defense (DoD) conducts R&D. One trend is the fact that budgets for R&D (in real dollars) will continue to decrease. Also the development of commercial high tech industries will continue to be a source of innovation for military procurements in some industrial sectors. With the shrinking of the federal R&D budget and the proliferation of technology, Federal laboratories need to find alternative ways to leverage their R&D through alliances with industry.[1] Industry also prefers to leverage their own R&D efforts by exchanging ideas, accessing unique facilities, and building on the work the labs have done.[2]

The purpose of technology transfer is to make federally generated scientific and technological developments accessible to private industry and the state and local governments. The users are then encouraged to develop the technology further into new products, processes, materials, or services that will enhance the nation's industrial competitiveness or otherwise improve the nation's quality of life. The Cooperative Research and Development Agreement, CRADA, is one technology transfer mechanism.

CRADAs join the Government and industry in mutually beneficial research, and although they represent only a small fraction of the federal R&D budget, they leverage money in the public and private sectors, causing an economic impact far larger than that suggested by the program budgets alone.[6]

Since 1986, when the CRADA mechanism was extended to DoD through the Federal Technology Transfer Act of 1986, there has not been an assessment of the benefits that this mechanism has returned to DoD. A prior GAO study[7] did review the role of CRADAs in successfully transferring technology to the private sector, however, this study evaluated 10 CRADAs from DoD, DoC, DoA, and HHS. Another study[8] conducted by David Roessner et al, provided some insight into how industry feels about collaborating with Federal laboratories, including the DoD. Roessner's study surveyed Chief Technical Officers and laboratory or R&D Division Directors of companies associated with the Industrial Research Institute, a professional trade association in Washington, DC. For this study, the Office of the Secretary of Defense, Director Defense Research and Engineering (DDR&E) is interested in understanding what is being accomplished through the use of the CRADA mechanism and the impact these accomplishments are having on the Labs' mission.

The flexibility of the CRADA mechanism makes it an important tool for forming partnerships. The following chart shows some of the many uses of the CRADA mechanism.

*Uses of the CRADA Mechanism*

- Knowledge-Share
- Information Exchange
- Facility Use
- Personnel Exchange
- Technical Assistance

In assessing the value/benefit that CRADAs bring to the DoD, one needs to define what constitutes a successful CRADA and what value is as it relates to the DoD mission. The success of a CRADA can be difficult to quantify. Some believe that a CRADA is successful when partners fulfill their intentions as stated in the statement-of-work. While one can sometimes point to tangible outcomes to measure success, quite often the benefits are intangible. The following chart has a sampling of tangible and intangible outcomes that can result from a CRADA.

*Possible Outcomes from a CRADA*

- Access to State-of-the-Art Technologies
- New or Improved Product
- New or Improved Process
- Patent
- Cost Avoidance
- Advanced Knowledge
- Leveraging of R&D
- Formation of New Relationships

The value of a CRADA to DoD can be identified in the requirements of the CRADA itself, that the objectives of the CRADA be consistent with the DoD laboratory's mission. In the framework of this report, a CRADA supports the laboratory mission if it meets one or more of the management principles, as described in the Defense Science and Technology Strategy.

It is the objective of this study to evaluate a sample of DoD CRADAs to assess the benefits that DoD is reaping from participation in these agreements. This report starts out with an overview of technology transfer legislation and the role of the CRADA mechanism in technology transfer. A summary of the CRADA sampling selection process is outlined as well as a synopsis of the methodology used in assessing the benefits of CRADAs to DoD. A series of generalized and specific findings on the CRADA mechanism are presented with supporting information from the CRADAs in this study. The value of CRADAs to the DoD S&T program is determined by tying each of the CRADAs selected in this study to the five management principles as defined in the Defense Science and Technology Strategy. Lastly, a CRADA from each of the three services, is showcased in detail to illustrate its value to the DoD and the private sector partners. Summaries of each of the CRADAs evaluated in this study, interview guides, Point-of-Contact lists, and a bibliography are provided in the Appendices.

# II. Overview of Technology Transfer and the DOD

Technology Transfer (TT) is the exchange of technology between the public and private sector, between the federal agencies and academia, or any combination thereof. TT includes[9] spin-off, dual-use, and spin-on activities that allow DoD programs to make the best possible use of national scientific and technical capabilities as well as provide technologies for non-defense applications. TT is also envisioned to incorporate innovative technology into military systems as well as to meet mission needs at a lower acquisition cost by taking advantage of the economies of scale by purchasing from a larger industrial base.

Policy guidance for DoD Domestic Technology Transfer and Dual-Use Technology Development (DTT/DUTD) initiatives was introduced in a June 1995 Secretary of Defense memo. The memo lays out the formal DoD policy on DTT/DUTD issues. "DoD Domestic Technology Transfer/Dual Use Technology Development (DTT/DUTD) are integral elements of the Department's pursuit of its national security mission. They must have a priority role in all DoD acquisition programs and must be recognized as key activities of the DoD Labs."[4] For laboratories, the memo states: "All DoD labs, as defined by 15 U.S.C. §3710a(d)2, and other organizations responsible for RDT&E activities must make DTT/DUTD a priority element in the accomplishment of their science and technology programs."

Other observers have also noted that profound political, budgetary and technological trends are creating a new paradigm for greater technology partnering between labs and industry. Dr. Janet S. Fender of the Air Force Research Laboratory, Kirkland AFB, indicated at the 1996 FLC National Technology Transfer Meeting in Albuquerque, NM, that a number of DoD professionals in technology transfer, RDT&E policymakers, and managers acknowledge that a changing paradigm in DoD S&T (See Figure 1) is under way.

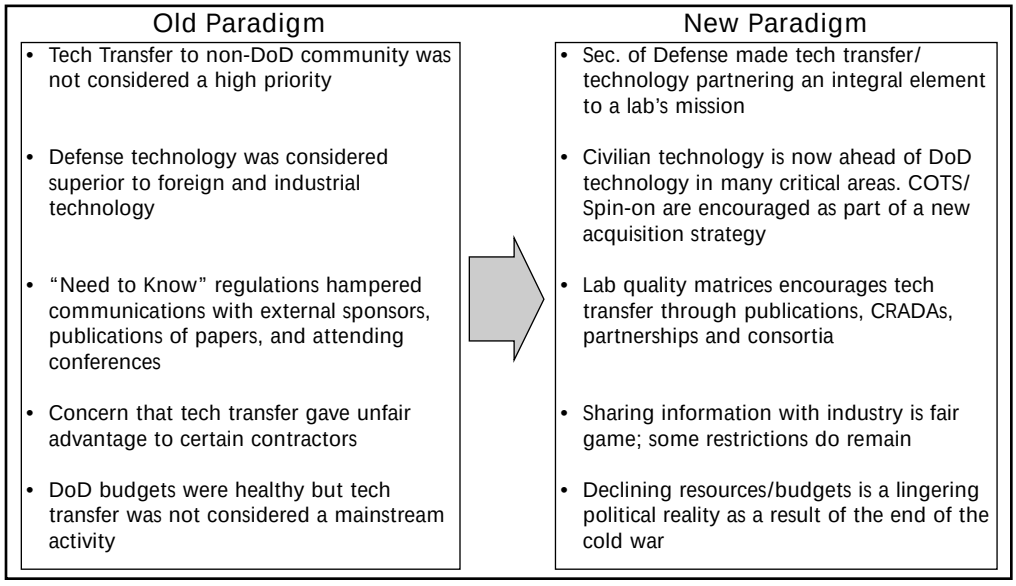



Figure 1. DoD Culture: Old and New

The DoD laboratories are also struggling to deal with technological shifts in the national climate. As a result of massive private sector advances and investments, the commercial sector is far ahead of the DoD in some critical information technologies. A Defense Science Board - Lab Management (DSB-LM) Interim Report[10] states that: "The laboratory system has not kept pace with the changing patterns of technology generation. No longer does the Defense Department

drive all militarily critical, cutting edge technologies. American industry, universities, and other government agencies play significant roles. The laboratory system must also develop a strategy for coping with fewer resources...."

The report goes further to state that "Labs, particularly for S&T functions, must maximize opportunities for collaborative interaction of government staff with their counterparts in other labs (e.g. NASA, DOE, DoC), industry and academia....Lab Directors must continuously search for technological, intellectual, and operational solutions outside the confines of their lab's mission and technical competence...."

The report identifies and recommends TT and partnering activities as important to laboratory modernization. "Labs should have a formal program to exploit all available mechanisms for S&T "spin-out, spin-in, and spin-up" in appropriate areas. Such mechanisms include CRADAs, grants, and cooperative agreements, collaborative proposals... contractual provisions for joint R&D, facility sharing, as well as personnel interactions essential to the transfer of tacit technology. To make such programs effective, Defense labs must earn the trust and respect of university and industrial partners; labs are a sponsor and collaborator, and should neither be, nor be seen as, a competitor. Labs also must promote the transfer to industry of their codified technology through patents, copyrights and licenses."

Similarly, "In an era of shrinking budgets and expanding global competition for cutting edge technology, the Air Force believes, and industry agrees, that government and industry R&D coordination is essential for the advancement of technologies integral to continued US strategic leadership."[11]

In addition, the intent of Congress has remained essentially the same for many years: leveraging federal R&D dollars for the greater good of the economy. The expectation has been that more partnerships between industry and Federal labs would improve U.S. competitiveness, help small businesses, and create new jobs and products for the nation's economy. Therefore, the FY93 Defense Authorization Act established the Office of Technology Transition within the Office of Secretary of Defense to ensure "that technology developed for national security purposes is integrated into the private sector of the United States in order to enhance national technology and industrial base, reinvestment, and conversion activities...."[3]

As illustrated in the Secretary of Defense memorandum, the OSD clearly encourages TT activities to promote cost sharing of DoD R&D through dual-use initiatives; integration of commercial technology through "spin-on" mechanisms, as well as making existing technology more affordable and accessible through spin-offs.[4]

## Technology Transfer Legislation Related to CRADAs

The Stevenson-Wydler Technology Innovation Act of 1980 is one of the cornerstones of technology transfer. CRADAs, created as part of the Stevenson-Wydler Act and extended to DoD in 1989, are a visible symbol of increased industry-government cooperation. The CRADA mechanism is just one mechanism from which technology transfer can be accomplished.

Although there are several pieces of legislation that pertain to issues related to technology transfer, only those related to CRADAs will be mentioned as background for this study. In addition to the Stevenson-Wydler Technology Innovation Act of 1980, the Federal Technology Transfer Act of 1986 (TTA), Executive Order 12591: Facilitating Access to Science and Technology, the National Technology Transfer and Advancement Act of 1995, or the Morella Act, and the pending Technology Transfer Commercialization Act of 1998 are legislation specific to CRADAs.

*Legislation Specific to CRADAs*

- Stevenson-Wydler Technology Innovation Act of 1980 (PL 96-480)
- Federal Technology Transfer Act of 1986 (PL 99-502)
- Executive Order 12591, The Facilitating Access to Science and Technology
- National Technology and Advancement Act of 1995 (Morella Act) (PL 104-113)
- Technology Transfer Commercialization Act of 1999 (H.R. 209) (pending)

The Stevenson-Wydler Technology Innovation Act of 1980[12] directed the Secretary of Commerce to improve the economic, environmental, and social well-being of the United States by promoting technological development. The Act appointed an office within the DoC to serve as a clearinghouse for federally-owned or originated technical information with potential application in state or local government or private industry. This Act also established the Offices of Research and Technology Applications (ORTAs) at each Federal agency to coordinate and assist with transferring federal technologies, products, and services to the private sector.

The Federal Technology Transfer Act of 1986[13] amends the Stevenson-Wydler Technology Innovation Act of 1980 to authorize Federal agencies to permit the directors of their Government-operated Federal laboratories to enter into CRADAs with other Federal agencies, state or local governments, industrial organizations, non-profit organizations, consortia, academic institutions, and other persons. The Act also allows for the negotiation of patent licensing agreements. For the purposes of CRADAs, the Act requires Federal agencies to make separate determinations of the missions of each laboratory and dictates that the activities carried out under the auspices of technology transfer be consistent with mission responsibilities.

The Act authorizes Federal laboratories under CRADAs to: 1) accept, retain, and use funds, personnel services, and property from collaborating parties and provide personnel services and property to collaborating parties; 2) grant patent licenses or assignments, or options, in any subject invention made by a federal employee, or made jointly by a federal employee and an employee of the collaborating party, and to retain such rights as the laboratory deems appropriate; 3) waive, subject to reservation by the Government of a nonexclusive, irrevocable, paid-up license to practice the invention or have the invention practiced throughout the world by or on behalf of the Government, in advance, in whole or in part, any right of ownership which the Federal government may have to any subject invention made by a collaborating party or such party's employee under the agreement; and 4) to the extent consistent with applicable agency requirements, permit employees or former employees of the laboratory to participate in efforts to commercialize inventions they made while in the service of the United States. The act also sets forth rules and formula for the distribution of royalties received by Federal agencies from the licensing of inventions.

Executive Order 12591: Facilitating Access to Science and Technology[14] encourages the facilitation of CRADAs with other Federal labs, state and local governments, universities, and the private sector in order to assist in the transfer of technology to the marketplace. It also establishes requirement for review of CRADAs with foreign persons or industrial organizations.

The National Technology and Advancement Act of 1995,[15] or the Morella Act, addresses intellectual property issues arising from CRADAs. Under the Morella Act, a laboratory may grant, or agree to grant in advance, to a collaborating part, patent licenses, assignments, or options in any invention made in whole or in part by a laboratory employee under the agreement, for reasonable compensation when appropriate. Under the CRADA, the laboratory will assure that the collaborating party has the option to choose an exclusive license for a pre-negotiated field of use for any such invention under the agreement or, if there is more than one collaborating party, that the collaborating parties are offered the option to hold licensing rights that collectively encompass the rights that would be held under such an exclusive license by one party. In addition, the collaborating party may retain title to any invention made solely by its employee in exchange for normally granting the Government a nonexclusive, nontransferable, irrevocable, paid-up license to practice the invention or have the invention practiced throughout the world by or on behalf of the Government for research or other Government purposes.

Technology Transfer Commercialization Act of 1999 (pending)[16] improves the ability of Federal agencies to license federally owned inventions by allowing collaborating parties in a CRADA, access to the rights of pre-existing technology performed in the technical area encompassing the CRADA without requiring advertisement of the pre-existing technology. In addition, the Act requires a license applicant to make a commitment to achieve practical utilization of the invention within a reasonable time and requires periodic reporting on the use of the invention by the licensee only to the extent necessary to enable the Federal agency to determine whether the licensee is complying with license terms.

## The CRADA's Role in Technology Transfer

As recently stated by the House Science and Technology Committee, "A CRADA, as envisioned at the time of the passage of the Federal Technology Transfer Act of 1986, was designed to help move individual ideas from the Federal laboratories into the private sector or lead to cooperation between industry and government labs in areas of mutual interest..."[16]

A CRADA is an agreement between one or more Federal laboratories and one or more non-federal parties. Under a CRADA, the government laboratories provide personnel, services, facilities, equipment or other resources with or without reimbursement. However, funds cannot be transferred from the federal partner to the non-federal partner. The non-federal parties provide funds, personnel, services, facilities, equipment or other resources toward the conduct of specified research and development efforts that are consistent with the missions of the laboratory. The CRADA partners share in the intellectual property developed under the effort. A CRADA is not a procurement contract or a cooperative agreement as Section 6303 et seq. of Title 31 of the United States Code uses these terms. Consequently, in awarding a CRADA to a collaborating party, the laboratory director is not required to comply with the FAR.[17] However, a CRADA is a legally binding document.

Under federal law, works created by employees of the Government cannot, except in rare circumstances, be copyrighted (17 U.S.C.§ 101-801, Copyrights). Works created under this agreement solely by the collaborating party or jointly with employees of the Federal laboratory may be copyrighted and owned by the collaborating party. The Government requires a non-exclusive, irrevocable, paid-up, worldwide license in all copyrighted software or other works developed under the CRADA. This license would enable the Government to use, duplicate, or disclose the copyrighted works for Government purposes only. Congress is considering changes to the law that would permit the Government to copyright software created under the CRADA by employees of the Federal laboratory.[18]

*Guidelines for Developing a CRADA*

- CRADAs are agreements that allow one or more Federal laboratories and one or more non-federal parties to conduct specified R&D efforts that are related to and consistent with the DoD laboratory/activity's mission.
- CRADAs are not subject to terms for procurement contracts as required by 31 USC 6303-6305, but are contracts in the same sense that they are legally enforceable.
- Special consideration is to be given to small businesses or consortia involving small businesses.
- Preference should be given to businesses located in the U.S. or those which agree that products embodying inventions made under the CRADA or produced through the use of such inventions will be manufactured substantially in the U.S.
- CRADAs must contain provisions for a variety of intellectual property issues including data rights, property ownership, and the allocation of rights to future inventions/intellectual property.
- DoD laboratories may protect from public access certain commercially valuable information resulting from work under a CRADA for a period of up to five years.
- DoD laboratories can commit resources such as personnel, services, facilities, equipment, intellectual property or other resources with or without reimbursement, but cannot provide funds as part of the agreement. Non-federal parties can commit funds to the agreement as well.
- DoD laboratories receiving funds under a CRADA should maintain separate and distinct accounts, records and other evidence supporting expenditures under the CRADA.
- When licensing intellectual property, the DoD laboratory shall, at a minimum, retain a nonexclusive, nontransferable, irrevocable, paid-up license for use by the Government.
- The private non-federal partner must be given the option to choose an exclusive license for a prenegotiated field of use for any invention made in whole or in part by a laboratory employee.
- CRADAs shall be accomplished without actual or apparent personnel or organizational conflict of interest or violations of ethics standards.

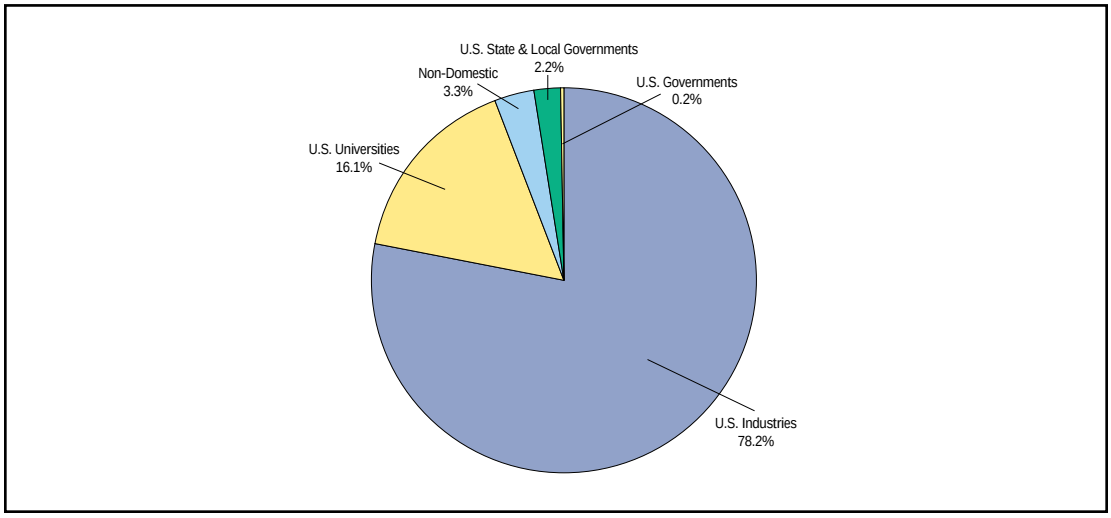
In certain instances, the Government may require the collaborating party to share with the Federal laboratory income received as a result of the sale or use of copyrighted works created under the CRADA. The length of time such payments remain in effect is negotiable, and in most instances the payments continue even after the termination of the CRADA.[19]

The table of guidelines and factors, provided here and laid out in the legislation, are to be considered when using a CRADA.[20]

## The Use of CRADAs:

The flexibility of the CRADA mechanism makes it one of the most important tools for partnerships. CRADAs are being used in new and creative ways such as for facility share agreements and even some personnel exchanges.

As shown in Figure 2, there is a broad mix of users of the CRADA mechanism. The industry sector is the largest user which includes both small and large businesses.




*Source: DTTIS*

*Total Count: 1774 (1039 active)*
*1995-June 1998*

Figure 2. Users of Defense CRADAs

A prior study[21] showed that there are different motivations for government and industry in joining a CRADA. Reasons laboratories have for engaging in TT activities include: 1) meeting legislative and OSD policy requirements, 2) improving laboratory quality and image by accessing commercial expertise and interacting with state and local R&D organizations, 3) enhancing mission capabilities by leveraging R&D dollars and by accessing commercial technologies and resources, and 4) contributing to the national economic well being by providing public access to DoD sponsored technologies.

In a survey conducted by Alden Bean, Lehigh University and J. David Roessner, Georgia Institute of Technology, Chief Technical Officers (CTOs) and laboratory or R&D Division Directors were queried on the factors involved in making the decision to collaborate with a Federal laboratory rather than with another external resource. These industry participants were gathered from the Industrial Research Institute (IRI), a professional trade association in Washington, DC. The IRI membership consists of approximately 270 large, research-intensive companies that account for 85% of R&D performed by U.S. industry. The survey showed that "companies are seeking technical information, expertise, access to specialized equipment, and new technology from outside sources in response to market pressure, tighter company budgets, and globalization of competition."[22]

Although this survey studied interactions in general between companies and the Federal laboratories and not just technology transfer interactions, cooperative research was ranked second in the types of interactions providing the highest payoff. Other types of interactions included: contract research, workshops/seminars/briefings, licensing of laboratory technology to industry, technical consultation, use of laboratory facilities, laboratory visits and information dissemination. "Informal interactions such as information dissemination, lab visits, seminars, and technical consultation occurred most frequently. The least frequent means of interaction were those that required the most paperwork, greatest investment of time, or greatest potential loss of research productivity such as technology licensing and employee exchange. Since a prior survey conducted in 1988, the frequency of interactions increased across the board with the greatest increases in contract research, cooperative research, and licensing suggesting that the legislative incentives intended to foster cooperative research with potential commercial applications are having a positive effect."[22]

The results from the survey went further to distinguish that leveraging of R&D, access to expertise and facilities, and business opportunities were the types of payoffs that can be expected from cooperative R&D. It was interesting to note that responses to this survey indicated that the most prevalent reason for industry interacting with a Federal laboratory was "access to unique technical resources." Some observers have assumed that commercialization potential would be the primary reason for industry/laboratory interactions, however, the survey found that it has only a "slightly positive" influence.

Since the 1986 authorization for DoD use of the CRADA mechanism, their use has increased dramatically as shown in Figure 3. This increase is due in part to increased familiarity with the mechanism, discovering the many types of collaborations that can be handled through the CRADA mechanism as well as the streamlining of the CRADA process through the delegation of signing authority and the development of Standard (Model) CRADA.

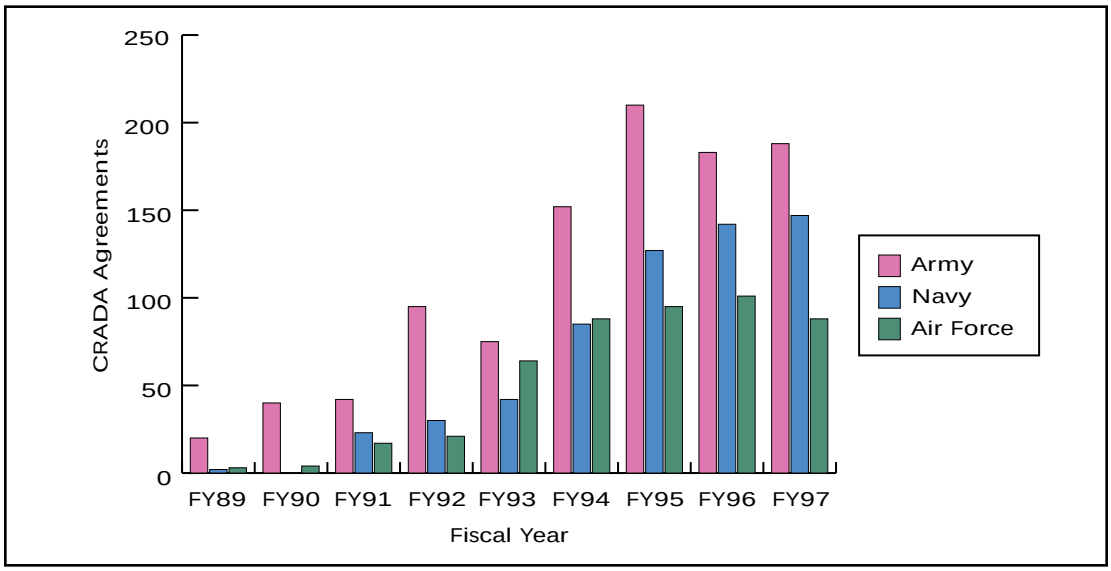



Figure 3. Defense CRADAs by Service
*(Source: TT Service Managers)*

One opinion is that the "rapidly rising curve of CRADA counts will level off as industry exploits the most promising opportunities for cooperative research."[23] Although this statement has some merit, as more industries become familiar with the technological potential that lies within the Federal laboratories as well as how to do business with the Federal laboratories, the use of the mechanism should continue to rise.

There are a number of "types" of CRADAs that have emerged since the inception of the CRADA mechanism. These versions of the CRADA have been developed to further simplify how industry can partner with the DoD.

The "Standard" CRADA, sometimes called the Model CRADA, permits the delegation of some CRADA signing authority to the laboratories which has streamlined the CRADA process tremendously. The standard CRADA permits automatic or accelerated approval, provided the language of the CRADA has not been modified (and/or a funding ceiling has not been exceeded). The Army, Navy, and Air Force, and sometimes the individual laboratories themselves, have slightly different standard CRADAs. Although the CRADA process is streamlined for the most part, the variation among the standard CRADAs can create difficulty in cooperation in those rare occasions when an additional Service joins a CRADA project (a new CRADA must be generated and signed). [24]

A "Blanket" CRADA, also referred to as a Master or Umbrella CRADA, is one of the variations on the CRADA mechanism gaining in popularity. Under this instrument, a CRADA is signed with an entire entity, like a county chamber of commerce, an association of small businesses, or an industry association. Usually these CRADAs are for technical assistance and often lead to traditional ("full blown") CRADAs for more sustained support. A blanket CRADA is unique in that it can set the stage for long term collaborations and facilitate complex strategic partnerships. To start a new effort, only the statement-of-work needs to be changed. The Army and Navy are pioneering this instrument.

For example, the Big Three automakers (Ford, General Motors, and Chrysler) have signed a blanket CRADA with the U.S. Army Tank-Automotive Research, Development and Engineering Center thereby fast-tracking future R&D between the automakers and the Army. The blanket concept has worked well for these partners in part because both industry and government had similar technical interests and the industries were located in close proximity to each other. Before this CRADA was established there was little interaction between the auto industry and the Army, despite similar needs; now this has changed significantly.

There are two additional types of CRADAs, the Technical Assistance CRADA and the Military Use CRADA, that are specifically defined in the DoD Draft Instruction on Technology Transfer.

The Technical Assistance CRADA allows a Federal laboratory and a non-federal partner to work jointly to assist local businesses by providing limited (4 day maximum) free technical consulting. In this case the non-federal partner is a state organization, university, non-profit entity, or business incubator that publicizes availability of federal assistance, receives and assesses requests for cooperative research, ensures the laboratory is not competing with private organizations and coordinates the laboratory's work with the requester companies. The laboratory provides the required assistance and reports to the CRADA partner and the requester company. The requester company merely provides a problem statement and signs a short 2-page "mini-CRADA" agreement.[25] The CRADA formed between the Naval Surface Warfare Center, Dahlgren Division and the Virginia Center of Innovative Technology (N9) is an example from this study of a Technical Assistance CRADA.

Some Services use CRADAs to develop technology specifically for military use/insertion. It has been argued that this may not be in keeping with the original intent of CRADA legislation, which is to develop commercial spin-offs. However, this type of CRADA use does fit with the goal of using CRADAs to extend diminishing laboratory resources toward fulfilling the military mission.[5] This type of CRADA, the Military Use CRADA, is an agreement between a DoD laboratory and an industrial partner to utilize existing unique capabilities and facilities at a DoD laboratory in a process or product intended primarily for DoD or other military use. Each participant recognizes that it cannot support the research alone and that duplicate existing research or facilities do not exist.[25] Two examples from this study that illustrate the Military Use CRADA were both at the Air Force Development Test Center, Eglin, AFB; one with Eastman Kodak (AF7) and the other with Hughes Missile Systems (AF9) (see appendices). In each of these CRADAs DoD testing facilities were used to demonstrate a particular capability of specific value to DoD.

Material Transfer Agreements, MTAs, although not actually CRADAs and therefore not included in the official CRADA counting process, are sometimes referred to as "CRADAs for Material Transfer (CRADA-MT)." These agreements are used when: 1) a party is providing material or information to a laboratory; 2) no collaboration beyond the transfer of the material or information is contemplated; 3) the laboratory is only to screen, test, or evaluate the material or information and provide a report of the results to the party providing the material; and 4) no funds, personnel, equipment or other resources are provided to the laboratory. The screening, testing and evaluating of the other party's material or information could result in new intellectual property and subsequent patent applications owned by the U.S. Government or jointly owned by the interacting but "noncollaborating" parties. Therefore, a service is not merely provided to the other party in a CRADA-MT, but research is conducted relevant to the laboratory's mission with the supplied materials. Even though no formal collaboration is intended, the inventive process, working in its own way, may result in joint inventions.

# III. Approach

## CRADA Sampling Selection Process

As of the time of this report, June 1998, there were a total of 2456 DoD CRADAs initiated since the inception of the Technology Transfer Act (TTA) of 1986. Of the 2456 CRADAs, 1256 were completed or closed-out. Initially the study was to focus exclusively on closed CRADAs, but this approach had numerous difficulties. Some of the difficulties encountered were 1) finding federal POCs who had retired or left the Government and 2) finding non-federal POCs whose companies no longer existed. Furthermore, there is not a requirement for a final or exit summary report. As a result, closed CRADAs as well as CRADAs that were open and had already exhibited some progress were considered in this study.

The CRADAs evaluated in this study may not be typical of the quality of all CRADAs. Since there is no requirement to track the outcomes of CRADAs, there may be CRADAs that have been notable, but their story has not been captured for multiple reasons such as, retirements and/or base closures. In addition, there is no common definition of value (i.e. metrics) other than through the stated objectives in the statement-of-work (and that the objectives be consistent with the laboratory mission). Therefore, it was determined that the most practical approach was to focus on the information from those CRADAs that were available and recommended by the Offices of Research and Technology Applications (ORTAs) as well as from interviews with CRADA participants.

This study is not meant to be comprehensive. Since it was not practical to evaluate all CRADAs, a sampling of 30 CRADAs were chosen for evaluation from a total of 131 CRADAs identified for this study. The majority of the CRADAs were nominated from the ORTAs at locations selected by the Technology Transfer Service Managers and judged to be of inherent value based on the laboratories' missions. Others were gathered from publications such as the Federal Laboratory Consortium *NewsLink*, Technology Business Magazine, Technology '95 (an Army publication), the 1996 In-House R&D Activity Report, and DoD laboratory web sites.

Of these 131 CRADAs, 86 CRADAs were chosen for further review based on whether they were closed or were open and already showing progress. Some were eliminated from the study if the sole benefit was to the non-federal partner. The final 30 CRADAs, 10 from each Service, that best illustrated value back to DoD were chosen based on availability of information and points-of-contact. A schematic of the downselection process is depicted in Figure 4.

Summaries of the 30 CRADAs selected for evaluation are provided in the appendices. These summaries are based on background information gathered from the original sources as well as interviews and correspondence with the points-of-contact. Information in the summaries were drawn upon to support the findings and benefits associated with CRADAs.

The interviews and analysis conducted for this study were performed from June 1998 through September 1998. Interview guides were used to conduct telephone interviews with both federal and non-federal CRADA POCs. In some cases the non-federal partner was not available to be interviewed. The interviews were open-ended in order to gain a better understanding of organizational motivations and salient issues. A copy of the interview guides are included in the appendices.

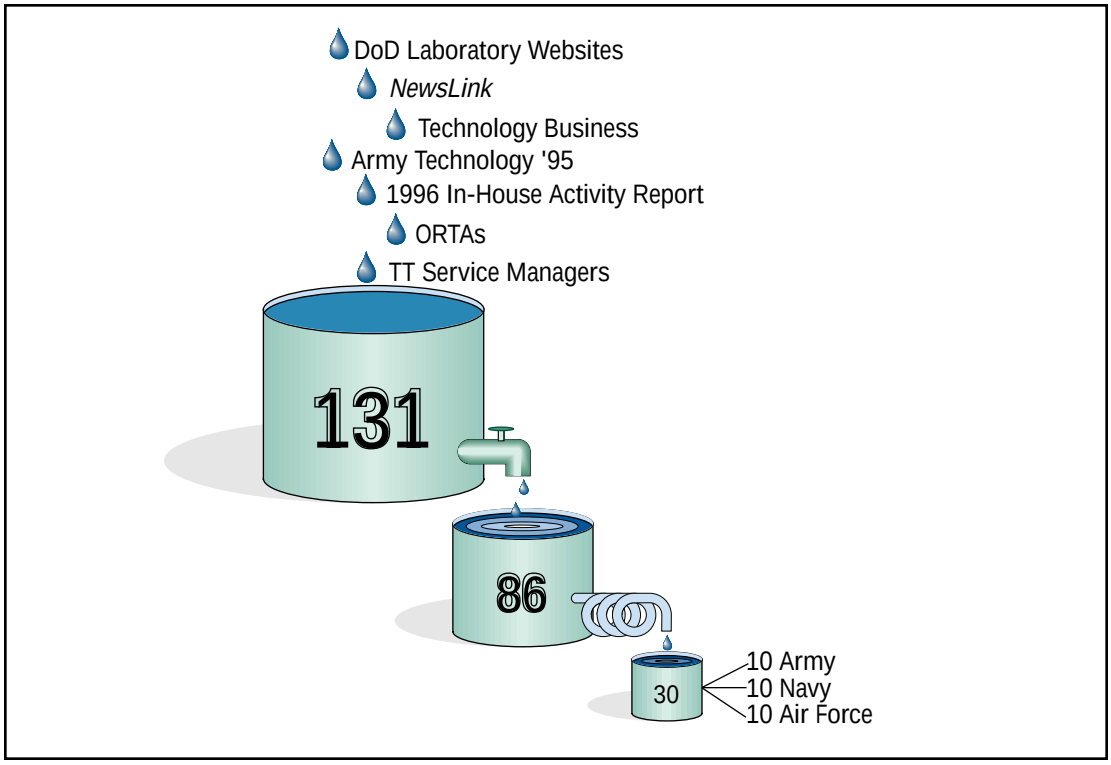



Figure 4. CRADA Sample Selection Process

## Assessing the Benefits of CRADAs to DoD

DoD has developed five management principles to guide in the development of the elements of the S&T programs of the Military Departments and Defense Agencies.

*Guiding Management Principles of the DoD S&T Program*

- Transition Technology to Address Warfighting Needs
- Reduce Cost
- Strengthen the Industrial Base
- Promote Basic Research
- Assure Quality

Aligning each CRADA to at least one of the five management principles from the Defense Science and Technology Strategy[26] was the primary method used in assessing the value of CRADAs to DoD. Additional anecdotal information supporting the success and value of CRADAs to DoD was gathered through interviewing both the federal and non-federal partners involved in the collaborations.

Within each of these management principles are broad criteria that DoD technology programs must meet. The following is a summary of the criteria for the five management principles outlined in the Defense Science and Technology Strategy.

### *Transition Technology to Address Warfighting Needs*

- Work with Warfighters
- Ensure that Joint Needs are Met
- Insert Promising Concepts into Development Programs Rapidly
- Insert Technology into In-Service System
- Prevent Technological Surprise

- Work with the Warfighters: Since it is the warfighters who must determine what capabilities are needed and therefore what systems will be purchased, technologists in the labs need to work with the users to articulate capability needs in order to match them with new technology opportunities.
- Ensure that Joint Needs are Met: The DoD S&T program gives high priority to joint needs, and ensures that technologies are being developed to serve joint forces. (i.e. integration of sensors, weapons, communications, situation displays, and navigation systems across the Services)
- Insert Promising Concepts into Development Programs Rapidly: Technology must move through a continuum rapidly, from new concept to research to technology exploration in the laboratory so that technology can be transitioned into military systems rapidly.
- Insert Technology into In-Service Systems: In-service systems should be upgraded with defense-unique, commercial-of-the-shelf (COTS), or subsystems (software, electronics, self-contained subsystems) whenever possible.
- Prevent Technological Surprise: Good intelligence is needed on weapon availability and the military concepts of potential adversaries. The S&T community must maintain a continuing awareness of emerging technology that could have military applications.

*Reduce Cost (both acquisition and life cycle costs)*

- Insert Technologies that Reduce the Cost of Ownership
- Use the Best Commercial Products, Practices, and Processes
- Simulate
- Improve Manufacturing Processes
- Consider Environmental Factors

- Insert Technologies that Reduce the Cost of Ownership: Technologists need to seek out technology and applications that reduce the cost of operating, maintaining, and upgrading systems and insert those technologies at every stage of the system's acquisition and life-cycle.
- Use the Best Commercial Products, Practices, and Processes: Exploit national and international commercial practices, standards, technologies, products, and protocols as the rule, rather than the exception. DoD-unique items need to be manufactured on flexible production lines. DoD needs to benefit from economies of scale.
- Simulate: The use of simulation allows technologists and warfighters to collaborate earlier in the development process, and provides users the means for a more thorough evaluation of concepts leading to substantial cost reductions.
- Improve Manufacturing Processes: Focus on easily reconfigurable manufacturing equipment that allows economical, variable-volume lot runs; integrated product and process development that permits production analysis during product design and tailoring of both product and process; and cost reduction of the combination of technology and manufacturing.
- Consider Environmental Factors: Develop and harness technologies to reduce the production of pollutants, reduce the cost of environmental clean-up and restoration, destroy munitions and systems in a more environmentally benign way, and isolate environmentally hazardous substances more reliably, at less cost and for a longer time. Address environmental issues early in the design phase of a new system.

*Strengthen the Industrial Base*

- Develop Dual-Use Technologies and Processes
- Sustain Service-Essential Disciplines and Industries
- Sustain Investment in Priority Technologies
- Exploit Commercial Technologies
- Strengthen Technology Transfer
- Field Selected Initiatives to Apply Technology to Societal Needs

- Develop Dual-Use Technologies and Processes: Dual-use refers to technologies, processes, and products with both military and nonmilitary applications.
- Sustain Service-Essential Disciplines and Industries: The Military Departments must bear the cost and responsibility for advancing these technologies and nurturing the research and development component of those industries.
- Sustain Investment in Priority Technologies: The current long-term investment initiatives in technology maturation include multi-chip modules, uncooled infrared focal plane arrays, microelectrical-mechanical systems, lithography, flat panel displays, titanium metal matrix composites, nano-manufacturing, and optical electronics.
- Exploit Commercial Technologies: The Services must monitor commercial product offerings and be the catalyst for the adoption of such products where they offer advantages. Incentives must be created to catalyze and facilitate insertion of commercial technology into defense systems.
- Strengthen Technology Transfer: DoD needs to ensure exploitation of commercial technology and nurture technology transfer among in-house laboratories, industry, universities and not-for-profit laboratories. Encourage shared use of facilities, and participation in regional, state and local alliances.
- Field Selected Initiatives to Apply Technology to Societal Needs: DoD will identify economic and societal needs where it has special ability to lead in the application of technology. These needs include counter-proliferation, environmental compliance, aviation, energy, infectious disease originating outside the US, and information systems.

*Promote Basic Research*

- Support Quality Basic Research
- Select Research Performers Based on Merit
- Sustain Stable Research Funding
- Promote Teamwork and Partnerships

- Support Quality Basic Research: DoD requires a basic research program to assure that it has early cognizance of new scientific ideas. DoD sustains its investment in basic research because it has proven experience of significant, long term benefits to the Military.
- Select Research Performers Based on Merit: Merit based selection of projects ensures quality.
- Sustain Stable Research Funding: To ensure that a supply of technical talent will continue, DoD must sustain its long-standing commitment to support students studying science and engineering. It continues the small, but important, programs to bring students to the Defense laboratories on cooperative or other arrangements in order to involve them first-hand in defense programs.
- Promote Teamwork and Partnerships: The DoD basic research program fosters teamwork and partnerships of many forms: DoD laboratory researchers teaming with in-service material engineers in the laboratories to explore jointly the symptoms of component failure; Defense laboratory scientists teaming with university or industrial scientists, perhaps drawn together to share use of laboratory equipment or instruments; consortia of universities and industry; and allies. Many programs involve close coordination between DoD and other government agencies.

*Assure Quality*

- Downsize, Outsource, and Restructure the DoD RDT&E
- Retain a Critical Mass of Internal Expertise
- Encourage Innovation
- Strengthen Defense S&T Reliance
- Monitor and Collaborate International Science Efforts

- Downsize, Outsource, and Restructure the DoD RDT&E Infrastructure: Today it may be more effective to rely on industry or universities for those technologies that are developing outside DoD at a rapid pace. Those portions of the infrastructure that are critical to the future must be retained, restructured as necessary, strengthened, and sized so as to be supportable with future DoD budgets.
- Retain a Critical Mass of Internal Expertise: Core competencies in military relevant technologies must be maintained.
- Encourage Innovation: The S&T leadership is responsible for encouraging innovation while at the same time allocating resources prudently.
- Strengthen Defense S&T Reliance: Defense S&T Reliance is an important vehicle for ensuring that the research efforts of the Military Departments and Defense Agencies are fully coordinated and not duplicative.
- Monitor and Collaborate International Science Efforts: No longer does the U.S. dominate world science and technology. Where appropriate, an increase in collaboration is needed with allies and emerging democracies, including the countries of the former Soviet Union, to reduce the possibility of technological surprise and ensure that access to leading edge research and key technology development is maintained.

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# IV. Findings on the Value of CRADAs

## Generalized Findings

Many interesting findings were deduced from the information gathered from the interviews with the federal and non-federal CRADA partners on their particular collaborations. There is a belief that CRADAs should lead to commercial products in order to be considered "successful." However, in actuality this appears to be the exception rather than the rule. CRADAs typically entail knowledge-share opportunities that facilitate advances in research that lead to product or process improvements, advancing research to points that would have taken longer to achieve independently, or allowing an opportunity to perform research that would not have otherwise occurred due to restricted funding resources.

The following findings were recurring themes described by participants in the collaborations. Each finding is exemplified by one CRADA from each Service as well as an accompanying table illustrating additional CRADAs from the study that support the finding. Detailed descriptive information can be found in the referenced CRADA summaries (Appendices A, B, and C).

- *Many Labs see CRADAs as "mission extenders" permitting joint government-commercial funding of important research areas where limited resources do not permit full government funding*

  CRADA partnerships can help both the civilian and Military Agencies better meet technological needs by exploiting commercial technologies and markets to meet the Government's needs.[27] The use of the CRADA mechanism to support the laboratory mission was a recurring theme in this study. Statements heard throughout the interviewing process such as "CRADAs can leverage R&D dollars for both the federal and non-federal partner," "CRADA reimbursements have resulted in revenue for the laboratories," "royalty payments can lead to revenue for a laboratory and its scientists," and "the CRADA mechanism is the only technology transfer instrument where industry can input money, but DoD does not" are indicative of the intention of using the CRADA mechanism as a mission extender. Estimates of the leveraged R&D efforts for each of the CRADAs evaluated in this study can be found in the following section, Specific Findings.

For example, the CRADA between Walter Reed Army Institute of Research and the Medical Technology and Practice Patterns Institute, Inc., (MTPPI), provided a means for ideas that would have otherwise been held captive in financially strapped laboratories to flourish in the commercial sector where there is interest and scientists available and ready to apply the technology. The transdermal vaccine delivery system currently being developed under this CRADA is a needle-free delivery system. Many vaccine manufacturers as well as the Navy and Institutes of Health have expressed interest in this needle-free vaccine delivery system for effective, safe, and easily administered delivery mechanism for vaccination. MTPPI inputs approximately $250K annually in funding for conducting the human trials of their vaccines at WRAIR. MTPPI also inputs approximately $500K in associated personnel costs. (A8)

The objective of an ongoing CRADA between the Naval Air Warfare Center Weapons Division (NAWCWPNS) China Lake and Thiokol Corporation is to develop and demonstrate the performance of high quality explosive fill for warheads with the ultimate goal of testing a warhead containing CL-20 based explosive that demonstrates performance significantly above that of existing explosives. Thiokol has the capability to produce the quantities required for weapon demonstration. China Lake will build and test the weapons to demonstrate their capabilities. (N3)

In an agreement with the U.S. Air Force Research Laboratory, Human Effectiveness Directorate (AFRL/HE), and Northrop Corporation the partners planned, designed, conducted, analyzed, documented, and reported on concept demonstrations of advanced Air Force direct attack conventional target acquisition and weapon delivery avionics systems. The Air Force received

and integrated into their simulator facilities, improved/enhanced aircraft flight and conventional weapon delivery and weapon flyout models that were not available through in-house R&D project funds. In this leveraged R&D effort, the Air Force received $300K in reimbursement costs from Northrop. (AF6)

*OTHER EXAMPLES*

| Number | CRADA Name | Remarks |
|---|---|---|
| A4 | CORE-LOC Concrete Armor Unit | • Revenue from royalties and reimbursable studies is helping to leverage R&D funding<br>• Annual royalties could exceed $1M from international sales |
| A10 | Vaccines for Infectious Diseases | • Ora Vax has input approximately $300K/year for overhead and equipment associated with the development of vaccines<br>• Ora Vax has four employees working on site at WRAIR |
| N6 | Exploring the Effects of Lipid-Lowering Agents on Complex Cognitive and Performance Tests | • $300K was input for labor and materials associated with effort to study the side effects of two cholesterol-lowering medications on cognitive performance |
| N8 | Ocean Bottom Profiler Joint Program | • R&D dollars were leveraged to meet objectives in the development of the Ocean Bottom Profiler |
| AF1 | Automated Software for Composite Material Analysis | • A software package was developed consisting of solution procedures for the efficient analysis of composite materials<br>• The Air Force has received $2K to date in royalties from the sale of the software to industry |
| AF2 | Covert Adjustable Laser Illumination | • An integrated system of a fiber coupled diode laser to illuminate an image from a gimbaled assembly was derived from the core competencies of both partners |
| AF3 | Hazardous Materials Management System | • The LINDEN™ hazardous materials tracking software was developed under a contract and Beta tested under the CRADA at the Air Force Research Laboratory<br>• The commercialization of this product has generated $4K in royalties for the Air Force |
| AF8 | USAF CRADA Between Weber State University and the Science and Engineering Laboratory | • Faculty and staff of Weber State University are provided access to Air Force laboratory equipment as well as to expertise<br>• Cost for analyses performed at the Air Force laboratory are reimbursed |

• *A CRADA can provide a means for industry to talk openly with government; proprietary information and intellectual property issues are handled in the CRADA negotiation. The ORTA can be instrumental in these negotiations.*

> Concerned over issues related to intellectual property, in the past industry has been reluctant to partner with the Federal laboratories. The CRADA mechanism provides a means of protecting company secrets by addressing intellectual property concerns up front in the negotiation process and writing them into the document itself.

For example, intellectual property and proprietary issues were major concerns of Goodyear Tire and Rubber and Caterpillar, Inc when they wanted to enter into a working partnership with the U.S. Army Cold Regions Research and Engineering Laboratory. The CRADA vehicle addressed these concerns in the negotiated agreement. Although the CRADA took longer to negotiate than had been originally anticipated, it was vital in bringing about this three party working relationship. (A3)

Although the technical POCs were eager to work together, initially Thiokol was reluctant to enter in the working relationship with the U.S. Naval Air Warfare Center, China Lake to manufacture the CL-20 explosive ingredient due to intellectual property issues. As a result of a secrecy order on the China Lake patented process for making CL-20, Thiokol had developed and patented a process of their own which entailed a slight modification to one of the original steps. When the

secrecy order was lifted, Thiokol wanted to license the China Lake process. NAWC licensed the technology to Thiokol for a minimal fee. (N3)

*OTHER EXAMPLES*

| Number | CRADA Name | Remarks |
|---|---|---|
| A7 | Evaluation of Electron Cyclotron Resonance Plasma Technology | • The industry partner felt more comfortable establishing a CRADA before sharing knowledge with the government |
| N6 | Exploring the Effects of Lipid-Lowering Agents on Complex Cognitive and Performance Tests | • Industry partner greatly appreciated the detailed efforts taken by the ORTA in negotiating the agreement<br>• The carefully negotiated CRADA was instrumental in solving an issue that arose at the end of the CRADA over ownership of the generated data |

• *CRADAs are a means of advancing research to points that would have taken longer to achieve independently. Even when the objectives set forth in the CRADA aren't met, less money and time is spent going down the wrong path.*

In times of constrained R&D budgets, whether it be a small business, a large business or a DoD laboratory, everyone can benefit from leveraging expertise that lies outside of their own labs. Drawing upon external expertise can provide the means to overcome obstacles that can present themselves along the path to new discoveries or even determine that the path being pursued is leading to a dead-end and another needs to be followed.

After only one year, Texas Instruments and U.S. Army Communications and Electronics Research, Development and Engineering Center, Night Vision and Electronic Sensors Directorate were successful in achieving milestones toward the development of a plasma etching manufacturing process for the development of next generation focal plane arrays. According to the participants interviewed, had each partner pursued this work individually, progress to this point would have taken several years. (A7)

The objective of an initial CRADA between the Naval Research Laboratory and Quantum Magnetics was to look at using quadrupole resonance to detect heroin hydrochloride and cocaine hydrochloride, but the signal proved very difficult to see. It was determined that the objectives of the initial CRADA were too aggressive. Therefore, a second CRADA was negotiated to focus on specific advanced circuitry to detect narcotics and explosives. It was noted that this collaboration provided a faster way to explore solutions thereby saving time and R&D dollars. (N4)

Similarly, a partnership between Northrop Corporation and the Air Force Research Laboratory Human Effectiveness Directorate, allowed actual warfighters to use and provide feedback on Northrop's target acquisition and weapon avionics system. This early feedback was used to modify and improve the design early in the development cycle, saving Northrop and the Air Force time and money. (AF6)

*ANOTHER EXAMPLE*

| Number | CRADA Name | Remarks |
|---|---|---|
| N1 | CRADA Between the Naval Training Systems Center and the Computer Group of Motorola, Inc. | • Had there not been a CRADA mechanism, both partners would have pursued the same work individually, taking longer to obtain similar results |

• *CRADAs can provide access to government/military facilities that are not otherwise commercially available resulting in first hand experience with future capabilities as well as reimbursements to the Federal labs.*

There are a limited number of test sites available to industry for the testing of new systems. Unique facilities exist that are important for DoD to maintain, but are not fully utilized on a daily basis. CRADAs can be used to arrange for the use of a particular test site or laboratory facility that is not otherwise commercially available (without competing with commercial labs or facilities). Allowing industry access to unique

facilities can offset the cost in maintaining critical internal expertise in military relevant technologies.

A CRADA between Walter Reed Army Institute of Research and Ora Vax, Inc. allows Ora Vax employees to utilize WRAIR facilities for their vaccine production. The WRAIR controlled laboratories are unique facilities that are required for the production of vaccine for Phase I and Phase II clinical trials. In times of shrinking budgets, the funds input to WRAIR by Ora Vax (approximately $250K) provide resources and revenue to support the laboratory and increase the usage of the facility. (A10)

In a CRADA between Hughes Missile Systems and the Air Force Development Test Center at Eglin AFB, Hughes used an Air Force arena test facility to test a warhead design. Hughes reduced their financial risk by not having to build their own test facility and Eglin AFB benefited by having $58K in direct support costs reimbursed. (AF9)

*ANOTHER EXAMPLE*

| Number | CRADA Name | Remarks |
|---|---|---|
| AF5 | Ogden Air Logistics Center X-Ray/Computed Topography Sections | • ARACOR needed access to demonstration sites for testing and qualifying new hardware and software being developed to enhance the Computed Topography machine's capabilities<br>• ARACOR partner reimbursed the Air Force $75K for associated direct support costs |

• *A CRADA can result in new, improved, or more cost effective products and processes sometimes leading to the development of a commercial supplier/resource to DoD.*

Although some feel that technology transfer is the process of identifying and transferring commercially viable technologies to the private sector, CRADAs typically entail small advances in research leading to product or process improvements. However, sometimes CRADAs do lead to new, commercializable products which provide the DoD with more affordable procurements that meet their technological needs. A table showing the products and product improvements resulting from the CRADAs evaluated in this study can be found in the following section, Specific Findings.

The Navy was using a fluorinated polyurethane paint as the top coat for their Navy Facilities Engineering Command, Navy Facilities Guide Specification 09872, four-coat paint system for coating the inside of petroleum storage tanks. This top coat cost $750.00 per gallon. 21st Century Inc. licensed the technology for the fluorinated polyurethane from the Naval Research Laboratory and combined it with technology from other patents and developed a three-coat variant paint system called WC5, Navy Facilities Guide Specification 09970.

21st Century tested this new paint system at the Naval Research Laboratory paint shop facility. The top coat on the WC5 paint system is a highly fluorinated coating that is very stable, flexible, chip resistant, UV resistant, and hydrophobic. As an example of the cost savings, a tank that is 40 feet in diameter by 35 feet in height coated with the old system would cost approximately $29,714.00 compared to the same tank coated with the WC5 system costing approximately $12,952.00. The savings just in the application costs in going from a four-coat process to a three-coat process is $2,827.44. WC5 is now used on Navy petroleum storage tanks as well as those of the Army Corps of Engineers. (N7)

Under a CRADA, Adtech Systems Research and the Air Force Research Laboratory, Materials and Manufacturing Directorate, were able to develop a fully documented commercial software package, Automated Software for Composite Analysis (ASCA). This software package consists of solution procedures for the efficient analysis of composite materials that are leading to new and innovative avenues for developing optimum designs and establishing new goals. (AF1)

*OTHER EXAMPLES*

| Number | CRADA Name | Remarks |
|---|---|---|
| A5 | Development of Biodegradable Polymers | • A paper cup coated with a biodegradable plastic was developed and is sold under the name of "Biopol" |
| N1 | CRADA Between the Naval Training System Center and the Computer Group of Motorola, Inc. | • Efforts in working with the DIS interoperability standard resulted in three software products/tools that provide the interface between simulators |
| N3 | Demonstration of CL-20 Based Explosive Formulations | • Thiokol scaled-up their manufacturing capability of the CL-20 explosive ingredient becoming the only producer of CL-20 and currently the only commercial source of the ingredient<br>• Thiokol has been marketing the basic ingredient as well as end-product formulations for use in explosives and gun propellants |
| N8 | Ocean Bottom Profiler Joint Project | • Acoustic transducers, receiver arrays, and acoustic baffles were incorporated into the vehicle design that have made the profiler vehicle superior in performance to all bottom profiling vehicles worldwide |
| AF3 | Hazardous Materials Management system | • A software package to computerize and track hazardous materials was Beta tested at the Air Force Laboratory and subsequently commercialized |
| AF4 | Helmet Mounted Display (HMD) Fitness of Use | • KOPIN was provided access to an actual military maintenance environment for the evaluation of their HMDs for use as a maintenance tool<br>• The Air Force was able to provide valuable feedback to KOPIN on the use of the HMD resulting in a commercialized product |

- *CRADAs can eliminate interpersonal barriers that can arise in a contractual relationship.*

  Often times the success of a CRADA is the result of enthusiastic S&E's working together towards a common goal. To reduce bureaucratic burden as much as possible and streamline the approval process, each Service and even some individual laboratories within each Service have developed a model or standard CRADA.

The industry partner in the CRADA with the U.S. Naval Air Warfare Center, China Lake and Thiokol attributed the success of the CRADA to the true partnership relationship that is involved in contrast to the contractor/government relationship that typically exists with a contract. The partners are working together to develop and demonstrate the performance of high quality explosive fill for warheads whose performance is significantly above that of existing explosives. Thiokol has the capability to make the quantities required for weapon demonstration. China Lake will build and test the weapons to demonstrate their capabilities. (N3)

In a CRADA between the Air Force Research Laboratory, Human Effectiveness Directorate, and KOPIN Corporation, a Fitness of Use study was undertaken to examine the effectiveness of Helmet Mounted Displays (HMD) in mobile computing applications. This working relationship allowed the government and industry to work together as equal partners rather than in a typical contractor arrangement. KOPIN appreciated the opportunity to share information with the Air Force technicians who used their display. (AF4)

*ANOTHER EXAMPLE*

| Number | CRADA Name | Remarks |
|---|---|---|
| N1 | CRADA Between the Naval Training System Center and the Computer group of Motorola, Inc. | • The partners had a good working relationship; they had previously worked together under a contract as well as on trade shows in the area of interoperability for the networking of simulators |
| N8 | Ocean Bottom Profiler Joint Project | • The federal and non-federal partners had known each other for over 30 years and were very enthusiastic about working with each other |

- *CRADAs are successful when clear objectives are laid out.*

  As with any well run research program, a CRADA with clearly defined objectives and milestones provides a clear path for meeting research goals. Having a clearly laid out path to follow allows individuals to easily come and go during the course of the project.

The CRADA between Communications Electronics Command, Night Vision and Electronic Sensors Directorate and Silicon Graphics, Inc. could have been more successful if objectives had been laid out. After initially progressing, retirements and resignations by both partners occurred. Not having objectives laid out made it difficult for replacements to track what was supposed to be achieved. (A1)

In contrast, objectives and milestones were clearly laid out in a successful CRADA between Bristol-Myers Squibb and the U.S. Naval Aerospace Medical Research Laboratory to study the effects of two cholesterol-lowering medications on cognitive performance. The industry partner clearly defined the protocol which was incorporated into the written statement-of-work and thus attributed to the objectives being met. (N6)

*ANOTHER EXAMPLE*

| Number | CRADA Name | Remarks |
|---|---|---|
| N8 | Ocean Bottom Profiler Joint Project | • Objectives and responsibilities were clearly laid out<br>• Both partners agreed that "a CRADA shouldn't have too many objectives, but rather a few clearly defined ones" |

- *CRADAs can advance knowledge for both partners sometimes leading to new programs/contracts.*

  As was also found in a 1994 GAO report,[28] Federal laboratories and private companies collaborating on research can advance R&D programs. New knowledge can lead to advancing the research to the next level in the development cycle or can spawn new ideas leading to new R&D programs altogether.

The working partnership between the U.S. Army Research Laboratory (ARL) and the Composites Development Corporation allowed ARL to further its research in pultrusion manufacturing techniques which can produce stronger, lighter, and more durable materials more quickly and at lower costs. Each party learned a considerable amount about how tougher, hybridized resins can be processed successfully at low viscosities with pultrusion, as well as improved methods of "feeding" glass and carbon fiber into pultrusion die "on-the-fly." (A9)

In the CRADA between the Naval Surface Warfare Center, Crane Division and AdvanceTek, an Indiana not-for-profit organization, a partnership was formed with the two CRADA partners and Purdue University and Indiana University to advance basic research in methods of measuring the usable energy capacity in batteries. The research conducted under this CRADA will provide AdvanceTek with a basic understanding of battery technology which will promote long-term developments in the electric vehicle and hybrid electric vehicle technologies. This new knowledge may also lead to the effective use of batteries as a propulsion mechanism which is of interest to both the automobile and electric power generation industries. (N5)

In the CRADA between the U.S. Air Force Development Test Center at Eglin AFB and Hughes Missile Systems, knowledge was gained in the fragmentation pattern of a new warhead designed

by Hughes Missile Systems. This knowledge led to future contracts for Hughes in this technology area. (AF9)

*OTHER EXAMPLES*

| Number | CRADA Name | Remarks |
|---|---|---|
| A6 | Development of Novel Imaging System for Medical, Non-Destructive Testing & Investigation of Micro-electronic Circuits | • Knowledge gained in this CRADA led to the development of an array as part of an Small Business Innovative Research, SBIR, contract with the Air Force for use in non-destructive measurement of fatigue in airplane wings |
| A7 | Evaluation of Electron Cyclotron Resonance Plasma Technology | • Advancements toward the development of next generation focal plane arrays was achieved<br>• Knowledge was advanced in using plasma technology for cleaning wafer surfaces which has led to a new concept for forming microlenses<br>• Scientists at Night Vision and Electronic Sensors Directorate have published four technical papers in the technology area of plasma etching technology |
| N2 | Deep-Towed Acoustic/ Geophysical System | • Data on geophysical properties of seafloor sediments was gathered that otherwise would not have been attained |
| N3 | Demonstration of CL-20 Based Explosive Formulations | • A FY99 Navy ManTech program is planned to scale up the CL-20 production process |
| AF7 | Test and Evaluation of Imaging System | • Eglin AFB has experienced a workload increase at its test facilities due to other industrial partners seeking similar needs |

In addition to these findings, it was observed in this study that CRADAs that continue or are extended between organizations is an indicator of progress. What could be more indicative of a successful partnership than wanting to work together again? An example of this finding is illustrated in the CRADA between the Naval Undersea Warfare Center, Division Newport and Precision Signal where now that the work outlined in the agreement has been competed, the partners continue to work together and are in the process of negotiating a follow-on CRADA. Also, even though the CRADA between Ogden Air Logistics Center and Weber State University was originally a two-year agreement, the successful working relationship resulted in extending the CRADA for another year.

## Specific Findings

In supporting the belief that successful CRADAs should lead to commercial products, Table 1 depicts those products or product improvements resulting from the sampling of CRADAs evaluated in this study. Some of the products are either still in development or pending commercialization, however, they are at stages where they are considered to be viable products. In some cases, CRADAs provided a means for products to be further refined as a result of the data gathered by the industry partner from the use of DoD facilities or test sites.

In supporting the belief that CRADAs can leverage R&D dollars for both the federal and non-federal partners, Table 2 depicts estimates of the contributions by both partners. The chart clearly shows that by pooling resources through the use of CRADAs, DoD as well as the industry partner can stretch their limited R&D dollars resulting in larger research efforts than either party could fund on their own. These larger, leveraged efforts can result in meeting objectives in a shorter time period than it otherwise would have taken or may even result in meeting the objectives altogether by collaborating with experts in a particular technology area.

The work-in-kind contributed by both the federal and non-federal partners was estimated for 28 out of the 30 CRADAs evaluated in this study. The work-in-kind contributed by the federal participants was estimated to be $4,758,850.00 with that of the non-federal participants estimated to be $5,836,312.00. In extrapolating the figures for work-in-kind contributions for these 28 CRADAs, one can estimate the contributions for the 2456 CRADAs. In doing so, the estimate for work-in-kind for the federal partners is $417,419,128.00 and that for the industry

Table 1. Products Resulting from CRADAs

| | CRADA Title | Company | Product | Users | Comments |
|---|---|---|---|---|---|
| A3 | Construction Equipment Performance Optimization | Caterpillar, Inc. Goodyear Tire and Rubber Co. | • Design tool (currently unnamed) to simulate interaction between tires and deformable surfaces | • Army mobility models, virtual prototyping of vehicles, virtual proving ground concepts | • Product in development • Information on development is highly proprietary |
| A4 | CORE-LOC Concrete Armor Unit | A.R. Wijnberg | • CORE-LOC (previously developed at WES) | • A.R. Wijnberg, an engineering consulting firm, recommended CORE-LOC for application in S. Africa | • Model testing and prototyping of the new armor units by coastal community |
| A5 | Development of Biodegradable Polymers | Zenneca (ICI Americas, Inc.) | • Biodegradable coating for paper • Biopol cup (GSA product) | • Military use | • Cups manufactured by Sweetheart Cup Co. • Navy development effort for compliance with MARPOL Treaty |
| A8 | Formulation of Liposomal Transdermal Vaccine System and Other Novel Pharmaceuticals | MTPPI, Inc. | • Transdermal vaccine delivery system | • Soldiers • Citizens of Third World countries | • In-Vivo studies have been conducted • Product transition phase: Phase I trials for FDA approval |
| A9 | Full Scale Fabrication & Optimization of Composite Cylinder Processing | Composite Development Corporation | • Hockey stick | • Team USA | • Advances in Pultrusion manufacturing techniques |
| A10 | Vaccines for Infectious Diseases | Ora Vax, Inc. | • Vaccine for peptic ulcers • Vaccine for Japanese encephalitis | • Soldiers | • Products in development |
| N1 | CRADA Between the Naval Training Systems Center and the Computer Group of Motorola, Inc. | Motorola, Inc. | • Middleman • Aladdin • Daemon | • DMSTTIAC • DMSO • Joint Theater Missile Defense Command • NAWCAD • Others | • DIS software tools |
| N2 | Deep-Towed Acoustic/Geophysical System | Seafloor Sciences International | • DTAGS | • Navy (geoacoustic properties are important in Anti-Submarine Warfighter operations) | • Refurbished Navy system with upgraded navigation capability |
| N3 | Demonstration of CL-20 Based Explosive Formulations | Thiokol Corporation | • CL-20 (previously developed at NAWC) | • Possible Navy Warhead program • Explosives • Gun propellants | • Demonstration of the high performance of CL-20 for use in warheads |
| N4 | Detection of Contraband Narcotics by Nuclear Quadrupole Resonance/Fast Recovery Time Nuclear Quadrupole Resonance Detection | Quantum Magnetics | • Advanced circuitry to detect narcotics and explosives (previously developed by QM) | • US Customs • Airports • FAA • Embassies | • Incorporated into a larger commercial detection system – Qscann |
| N7 | New Paint Formulations for Fluorinated Polyurethane Resins | 21st Century Coatings, Inc. | • WC5: three-coat variant paint system | • AF Fuel storage tanks • Exxon • Navy petroleum tanks • Army Corps of Engineers | • Used to coat inside of petroleum storage tanks • Growing interest in product |
| N8 | Ocean Bottom Profiler (OBP) Joint Project | Precision Signal, Inc. | • 512 Sonar Vehicle | • Universities • Navy | • Mfg. and marketed by Edge Tech, Inc. |
| N9 | Technical Assistance to CIT | Virginia Center for Innovative Technology | • Sea Alert Hat (previously developed by small business) | • Navy • "Around Alone" skippers • Carried in "West Marine" Catalog | • Test site used for testing the radar reflectivity of product |
| N10 | Use of Spinning Microfilters to Separate Oil from Water for Abatement of Marine Oil Spills | Marine Spill Response Corporation | • Spinning microfilter separation process was developed | • Oil companies | • Process was patented |
| AF1 | Automated Software for Composite Material Analysis | AdTech Systems Research, Inc. | • Automated Software for Composite Analysis (ASCA) | • Boeing • Lockheed • United Technologies | • Software for efficient analysis of composite materials |
| AF2 | Covert Adjustable Illuminator CRADA | FLIR Systems, Inc. | • Product for active illumination in near IR to identify ships and aircraft | • Federal and local governments • Marine patrol units | • Commercial product is pending |
| AF3 | Hazardous Materials Management System | Modern Technologies Corporation | • Linden™ | • Center for Disease Prevention and Control • Army Redstone Arsenal | • Beta tested a contract-developed software at AFRL |
| AF4 | Helmet Mounted Display Fitness of Use | KOPIN Corporation | • Product assessment of helmet mounted display | • Potential: Military maintenance personnel | • Design was refined |
| AF5 | Ogden Air Logistics Center X-Ray/Computed Tomography Sections | ARACOR | • CT equipment upgrade | • DoE • DLA | • Product improvement |
| AF6 | Strategic Avionics Battle Management Evaluation and Research | Northrop Corporation | • Simulator upgrade | • Services | • Field tests provided data for upgrade to system |
| AF7 | Test and Evaluation of Imaging System | Eastman Kodak Company | • Product assessment of MITE system | • Incorporated into F15 | • Design was refined leading to commercial product |
| AF10 | Whole Spacecraft Isolation System for Taurus/GEOSAT | Orbital Sciences Corporation | • Whole Spacecraft Isolation System | • Future satellite systems | • System was built and evaluated |

partners is $511,927,938.00. The amount of "cash-in" that the DoD laboratories are receiving from CRADAs is significant and has been increasing over time as shown in Figure 5. These actual dollars that are coming into the laboratories cover such costs as overhead, materials, third party contracts, and travel expenses. The figures for both work-in-kind and cash-in illustrate the importance industry is associating with the CRADA mechanism as well as the significant contribution partnering is making to the DoD mission.

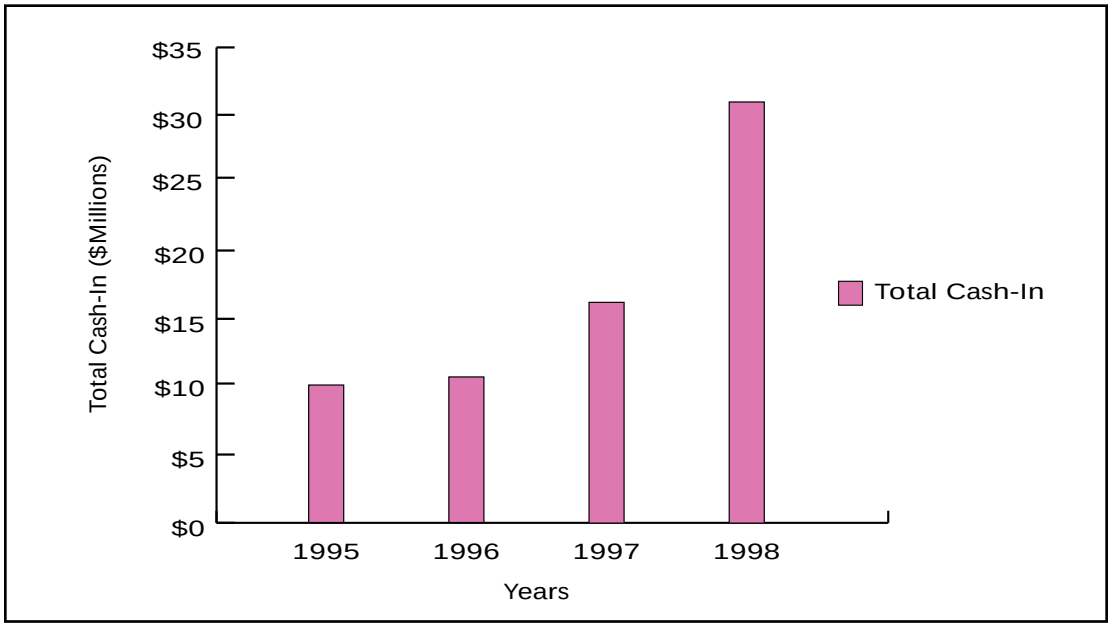


Figure 5. "Cash-In" for DoD CRADAs
*(Source: TT Service Managers)*

Table 2. Leveraged Efforts via CRADAs

| | CRADA Title | DoD Lab | Company | DoD input | Industry Input | Leveraged Effort |
|---|---|---|---|---|---|---|
| A1 | Advanced Technology for High Resolution Physics Based Interactive Simulation | U.S. Army CECOM, NVESD | Silicon Graphics, Inc. | 1/2 MY ($50K) | 1/4 MY ($25K) | $75K |
| A2 | Blanket CRADA Between Ford, General Motors, and Chrysler and the U.S. Tank-Automotive Research, Development, and Engineering Center | U.S. Tank-Automotive Research, Development, and Engineering Center | Ford Motor Company, Chrysler and General Motors | 24 MY ($2,400K) | 25 MY ($2,500K) | $4,900K |
| A3 | Construction Equipment Performance Optimization | U. S. Army Cold Regions Research and Engineering Laboratory | Caterpillar, Inc. Goodyear Tire and Rubber Co. | 5 MY ($500K) | 5 MY ($500K) | $1,000K |
| A4 | CORE-LOC Concrete Armor Unit | U.S. Army Engineers' Waterways Experiment Station | A.R. Wijnberg | 1/2 MY ($50K) | 1/2 MY ($50K) | $100K |
| A5 | Development of Biodegradable Polymers | U.S. Army Natick Research, Development and Engineering Center | Zenneca (ICI Americas, Inc.) | 400 hrs ($19.23K) | 2000 hrs ($96.15K) | $115.38K |
| A6 | Development of Novel Imaging System for Medical, Non-Destructive Testing and Investigation of Microelectronic Circuits | U.S. Army CECOM, NVESD | Marvin E. Lasser, Inc | 100 hrs ($4.8K) | 1 MY ($100K) | $104.8K |
| A7 | Evaluation of Electron Cyclotron Resonance Plasma Technology | U.S. Army CECOM, NVESD | Texas Instruments | 100 hrs ($4.8K) | 1/2 MY ($50K) | $54.8K |
| A8 | Formulation of Liposomal Transdermal Vaccine System and Other Novel Pharmaceuticals | Walter Reed Army Institute of Research | MTPPI, Inc. | N/A | 1/2 MY + $250K ($50K + $250K) | N/A |
| A9 | Full Scale Fabrication & Optimization of Composite Cylinder Processing | U.S. Army Research Laboratory | Composite Development Corporation | .3 MY ($30K) | .4 MY ($40K) | $70K |
| A10 | Vaccines for Infectious Diseases | Walter Reed Army Institute of Research | Ora Vax, Inc. | 3 MY ($300K) | 6 MY + $250K ($600K+$250K) | $1,150K |

Table 2. Leveraged Efforts via CRADAs (con't)

| | CRADA Title | DoD Lab | Company | DoD input | Industry Input | Leveraged Effort |
|---|---|---|---|---|---|---|
| N1 | CRADA Between the Naval Training Systems Center and the Computer Group of Motorola, Inc. | Naval Air Warfare Center, Training Systems Division | Motorola, Inc. | 1 MY ($100K) | 1 MY ($100K) | $200K |
| N2 | Deep-Towed Acoustic/Geophysical System | Naval Research Laboratory | Seafloor Sciences International | 8 months ($66.64K) | 7 months + $396K ($58.33K+$396K) | $520.97K |
| N3 | Demonstration of CL-20 Based Explosive Formulations | Naval Air Warfare Center, Weapons Division, China Lake | Thiokol Corporation | 1.5 MY ($150K) | 1 MY + $40K ($100K+$40K) | $290K |
| N4 | Detection of Contraband Narcotics by Nuclear Quadrupole Resonance/Fast Recovery Time Nuclear Quadrupole | Naval Research Laboratory | Quantum Magnetics | .1 MY ($10K) | 6 months ($49.98K) | $59.98K |
| N5 | Electric Vehicle/Hybrid Electric Vehicle Battery Chemistry Research and Evaluation | Naval Surface Warfare Center, Crane Division | AdvanceTek | .25 MY ($25K) | $400K in equipment | N/A |
| N6 | Exploring the Effects of Lipid-Lowering Agents on Complex Cognitive and Performance Tests | Naval Medical Research Institute | Bristol-Meyers Squibb | 5 months ($41.65K) | $302K | $343.65K |
| N7 | New Paint Formulations for Fluorinated Polyurethane Resins | Naval Research Laboratory | 21st Century Coatings, Inc. | 70 days ($27K) | 1.25 MY ($125K) | $152K |
| N8 | Ocean Bottom Profiler (OBP) Joint Project | Naval Undersea Warfare Center, Newport Division | Precision Signal, Inc. | 3.5 MY ($350K) | 3.5 MY ($350K) | $700K |
| N9 | Technical Assistance to CIT | Naval Surface Warfare Center, Dahlgren Division | Virginia Center for Innovative Technology | .04 MY ($4K) | 4 hrs ($.192K) | $4.192K |
| N10 | Use of Spinning Microfilters to Separate Oil from Water for Abatement of Marine Oil Spills | Naval Surface Warfare Center, Carderock Division | Marine Spill Response Corporation | 1 MY ($100K) | $250K | $350K |
| AF1 | Automated Software for Composite Material Analysis | AFRL/ML | AdTech Systems Research, Inc. | 2 MY ($200K) | 1.5 MY ($150K) | $350K |
| AF2 | Covert Adjustable Illuminator CRADA | AFRL/DE | FLIR Systems, Inc. | 1/2 MY ($50K) | 1.25 MY + $10K ($125K+$10K) | $185K |
| AF3 | Hazardous Materials Management System | AFRL/ML | Modern Technologies Corporation | 1.5 MY ($150K) | 3 MY ($300K) | $450K |
| AF4 | Helmet Mounted Display Fitness of Use | AFRL/HE | KOPIN Corporation | .2 MY ($20K) | 1/2 MY + $10K ($50K + $10K)) | $80K |
| AF5 | Ogden Air Logistics Center X-Ray/Computed Tomography Sections | Ogden Air Logistics Center | ARACOR | 1500 hrs ($72.12K) | 175 hrs + $75K ($8.41K+$75K) | $155.53K |
| AF6 | Strategic Avionics Battle Management Evaluation and Research | AFRL/HE | Northrop Corporation | 400 hrs ($19.2K) | 2.5 MY + $300K ($250K + $300K) | $569.2K |
| AF7 | Test and Evaluation of Imaging System | U.S. Air Force Development Test Center, Eglin AFB | Eastman Kodak Company | 1 month ($8.33K) | 3 months ($24.99K) | $33.32K |
| AF8 | USAF CRADA Between Weber State University and the Science and Engineering Laboratory | Ogden Air Logistics Center, Technology and Industry Support Directorate | Weber State University | 150 hrs ($7.2K) | 2900 hrs ($139.42K) | $146.62K |
| AF9 | Warhead Arena Test | U.S. Air Force Development Test Center, Eglin AFB | Hughes Missile Systems | 550 hrs ($26.44K) | 2 weeks + $58K ($3.84K + $58K) | $88.28K |
| AF10 | Whole Spacecraft Isolation System for Taurus/GEOSAT | AFRL/VS | Orbital Sciences Corporation | 30 hrs ($1.44K) | .3 MY ($30K) | $31.44K |

Assume: 1MY = $100K  N/A: not available  MY: Man-year  * Actual cash-in is shown as dollar values next to the estimates for man-years of effort

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## Army CRADAs

| | | Address Warfighting Needs | Reduce Cost | Strengthen the Industrial Base | Promote Basic Research | Assure Quality |
|---|---|---|---|---|---|---|
| A1 | Advanced Technology for High Resolution Physics Based Interactive Simulations | ● | ● | | ● | ● |
| A2 | Blanket CRADA Between Ford, General Motors, Chrysler and the U.S. Army Tank-Automotive Research, Development and Engineering Group | | | | ● | |
| A3 | Construction Equipment Performance Optimization | | | ● | ● | ● |
| A4 | CORE-LOC Concrete Armor Unit | | | ● | ● | |
| A5 | Development of Biodegradable Polymers | | | ● | ● | |
| A6 | Development of Novel Imaging System for Medical, Non-Destructive Testing & Investigation of Micro-electronic Circuits | | | ● | ● | |
| A7 | Evaluation of Electron Cyclotron Resonance Plasma Technology | ● | | ● | ● | ● |
| A8 | Formulation of a Liposomal Transdermal Vaccine System and Other Novel Pharmaceuticals | ● | | ● | ● | ● |
| A9 | Full Scale Fabrication & Optimization of Composite Cylinder Processing | | ● | ● | ● | |
| A10 | Vaccines for Infectious Desease | ● | | ● | | ● |

## Navy CRADAs

| | | Address Warfighting Needs | Reduce Cost | Strengthen the Industrial Base | Promote Basic Research | Assure Quality |
|---|---|---|---|---|---|---|
| N1 | CRADA between The Naval Training System Center and Computer Group of Motorola, Inc. | ● | ● | | ● | |
| N2 | Deep-Towed Acoustic/Geophysical System | ● | | | ● | |
| N3 | Demonstration of CL-20 Based Explosive Formulations | ● | | ● | | |
| N4 | Detection of Contraband and Narcotics by Nuclear Quadrupole Resonance (NQR)/Fast Recovery Time Nuclear Quadrupole Resonance Detection | | | ● | ● | |
| N5 | Electric Vehicle/Hybrid Electric Vehicle Battery Chemistry Research & Evaluation | | | | ● | |
| N6 | Exploring the Effects of Lipid-Lowering Agents on Complex Cognitive and Performance Tests | ● | | | | |
| N7 | New Paint Formulations for Fluorinated Polyurethane Resins | | ● | ● | | |
| N8 | Ocean Bottom Profiler (OBP) Joint Project | ● | | ● | ● | |
| N9 | Technical Assistance to CIT | | | ● | ● | |
| N10 | Use of Spinning Microfilters to Separate Oil from Water for Abatement of Marine Spills | | | | ● | |

## Air Force CRADAs

| | | Address Warfighting Needs | Reduce Cost | Strengthen the Industrial Base | Promote Basic Research | Assure Quality |
|---|---|---|---|---|---|---|
| AF1 | Automated Software for Composite Material Analysis | | | ● | ● | |
| AF2 | Covert Adjustable Laser Illumination CRADA | ● | | ● | | ● |
| AF3 | Hazardous Materials Management System | | ● | ● | | |
| AF4 | Helmet Mounted Display Fitness of Use | ● | | | ● | |
| AF5 | Ogden Air Logistics Center X-Ray/Computed Topography Sections | | | ● | ● | |
| AF6 | Strategic Avionics Battle Management Evaluation and Research (SABER) | ● | ● | | | |
| AF7 | Test and Evaluation of Imaging System | ● | | ● | | |
| AF8 | USAF CRDA Between Weber State University and the Science and Engineering Laboratory | | | | ● | |
| AF9 | Warhead Arena Test | | | | ● | |
| AF10 | Whole Spacecraft Isolation System for Taurus/GEOSAT | ● | ● | | ● | |

# V. Benefits of CRADAs to the DoD S&T Program:

## *Reflecting the DoD S&T Guiding Management Principles*

Technology superiority in military capabilities is the main objective of DoD's S&T program. Lower budgets are driving an increased emphasis on affordability, longer lived weapon systems, and insertion of new technology as well as developing dual use technologies where appropriate. Leveraging the scientific community to take advantage of progressive technologies for military applications is increasingly occurring.[26]

DoD has developed five management principles to guide in the development of the S&T programs of the Military Departments and Defense Agencies. These management principles, or elements, are designed to place the best mix of capabilities possible into the hands of the operational forces by leveraging the best resources in the DoD and the nation.[26]

*Guiding Management Principles of the DoD S&T Program*

- Transition Technology to Address Warfighting Needs
- Reduce Cost
- Strengthen the Industrial Base
- Promote Basic Research
- Assure Quality

Since CRADAs must support specific R&D efforts that are related to and consistent with the DoD laboratory's mission, it is reasonable to assume that if the CRADAs evaluated in this study reflect the DoD S&T guiding management principles, then they have added value to the DoD S&T program as a whole. In fact, many of the CRADAs evaluated met more than one of these management principles. Although there were many examples from this study from which to chose, a few examples are given here to illustrate how CRADAs are adding value to the elements of the DoD S&T effort.

### Transition Technology to Address Warfighting Needs

#### *Evaluation of Electron Cyclotron Resonance Plasma Technology (A7)*

Work in the area of focal plane arrays (FPAs) is one of the current DoD long-term investment initiatives in technology maturation. The Army is very interested in focal plane arrays for use as sensors in tanks, helicopters and missiles. These sensors act as an artificial retina and detect thermal radiation. They are used in heat seeking missiles where they can hone in on a target that is warmer than its surroundings and in night vision navigation applications. Army requirements for higher standoff distances and target recognition capability have led to concepts for a next generation of arrays whose pixels need to be considerably smaller and more closely spaced than those on currently available arrays.

The current industrial baseline process for producing focal plane arrays with mercury cadmium telluride has been to form mesas and trenches in the layers by dipping them into a liquid chemical etchant. All second generation focal plane arrays are manufactured with this technology. In a CRADA between the U.S. Army Communications and Electronics Research, Development and Engineering Center, Night Vision and Electronics Sensors Directorate (NVESD) and Texas Instruments (TI), the suitability of a new vapor phase etching process, Electron Cyclotron etching (ECR), as a potential replacement for liquid phase etching was explored.

After one year the etching process looks promising. A few milestones towards developing the next generation FPA via vapor phase etching have been achieved. The vapor phase etching process produced a FPA 128 pixels by 128 pixels with each pixel being 24 microns by 24 microns. Given that the largest FPA made by existing methods is 1024 pixels by 1024 pixels, more milestones still lie ahead. TI has now purchased a plasma reactor identical to the one used

at NVESD in order to continue the research effort and hope to eventually integrate this technology into their production line.

*CRADA Between The Naval Training Systems Center and the Computer Group of Motorola, Inc. (N1)*

The interfacing of simulators is highly desirable in the synthetic battlefield. The Distributed Interactive Simulation (DIS) interoperability standard provides a protocol for formatting messages that enable simulators to communicate with each other. The Naval Air Warfare Center, Training Systems Division and Motorola teamed in a CRADA to gain experience with the new DIS interoperability standard through jointly developing software to support networking of simulators using distributed interactive simulation.

Three software products/tools (Middle Man, Aladdin, and Daemon) resulted from the work performed under this CRADA . The Aladdin is a powerful DIS stealth application which enables the warfighter to view the synthetic battlefield from different perspectives including a "god's eye view." This software has been used in several other programs including Army and Air Force programs. Since Motorola does not hold intellectual property rights, these products are available to government agencies and their contractors free of charge.

*Ocean Bottom Profiler (OBP) Joint Project (N8)*

The Naval Undersea Warfare Center, Division Newport, (NUWCDIVNPT) and Precision Signal, Inc., (PSI) collaborated under a CRADA to develop state-of-the-art equipment known as the Ocean Bottom Profiler, OBP. The OBP was expected to be capable of producing three-dimensional images of the sub-bottom sea floor mapping the ocean floor in deep and shallow water as well as assisting in the study of the geomorphology of the bottom by returning information on sediment layers.

With this new vehicle, buried objects in the sea floor can be located and improved data for remote classification of the sea floor can be obtained. PSI and NUWCDIVNPT have worked to develop an array of receivers for electronic near-field beamforming objects in the sediment. Using previously developed acoustic transducer and acoustic baffle technology, a large, low frequency vehicle was constructed at PSI, and test data proved the feasibility of acoustic detection of buried objects in the sea floor. Acoustic sediment layers can now be measured in the ocean floor down to a level of 64 meters with a 9 cm resolution.

The results of these efforts significantly contributed to the design of the AN/WSQ-9 Sonar System, a NUWCDIVNPT initiative that will soon provide significant new warfighting capabilities in mine detection to the U.S. Submarine Fleet. The first installation of this capability into a U.S. submarine is planned for FY99.

## Reduce Cost

*New Paint Formulations for Fluorinated Polyurethane Resins (N7)*

The Navy was using a fluorinated polyurethane paint as the top coat for their Navy Facilities Engineering Command, Navy Facilities Guide Specification 09872, four-coat paint system (wash primer coat, zinc-rich urethane coat, urethane manufacturing coat and fluorinated top coat) for coating the inside of petroleum storage tanks. 21st Century Inc. licensed the technology for the fluorinated polyurethane from the Navy and combined it with technology from other patents and developed a three-coat variant paint system (two epoxy coats and a highly fluorinated top coat) called WC5, Navy Facilities Guide Specification 09970.

21st Century tested this new paint system at the Naval Research Laboratory paint shop facility. The top coat on the WC5 paint system is a highly fluorinated coating that is very stable, flexible, chip resistant, UV resistant, and hydrophobic. As an example of the cost savings, coating a tank that is 40 feet in diameter by 35 feet in height with the old system would cost approximately $29,714.00 compared to the same tank coated with the WC5 system which would cost approximately $12,952.00. The savings just in the application costs in going from a four-coat process to a three-coat process is $2,827.44. WC5 is now being used on Navy petroleum storage tanks as well as those of the Army Corps of Engineers.

### *Hazardous Materials Management System (AF3)*

The U.S. Air Force Research Laboratory, Materials and Manufacturing Directorate (AFRL/ML) uses more than 10,000 different chemicals in over 40,000 containers in its 15 facilities. This level of activity and complexity necessitates a very aggressive pollution prevention program to assure that health and safety are a top priority and that environmental issues are correctly managed.

The AFRL/ML, under a CRADA with Modern Technologies Corporation, developed a computerized system using bar code technology to coordinate the tracking and control of hazardous materials including levels, location changes, usage rates, and other critical data. The system, LINDEN™ Environmental Management System (LINDEN™), enables effective centralized hazardous materials management, waste minimization and pollution prevention efforts. It also reduces materials costs and prevents materials shortages through more effective control and retrieval. Using system data, the storage of hazardous chemicals is consolidated, helping to eliminate duplicate and excess stock.

At the Directorate, over 40,000 hazardous materials and waste containers were tracked throughout their complete use life, resulting in purging of over 10,000 hazardous material containers no longer needed by researchers. More than 400 containers of unknown materials were identified, classified and eliminated. In some cases, the effort permitted the identification of replacement chemicals that are less harmful to the environment. The system was extended to include laboratory facilities across Wright-Patterson AFB and has been selected for implementation at other government installations.

The value in using the LINDEN™ system to reliably manage a hazardous materials program at the AFRL/ML is conservatively estimated to be $10K in terms of equivalent contracting costs. The LINDEN™ system also saves labor hours that would typically be spent on documentation and tracking.

## Strengthen the Industrial Base

### *Construction Equipment Performance Optimization (A3)*

Current tire models do not consider the interaction of the tire with deformable media such as soil or snow, focusing only on interactions with pavements. An ongoing CRADA between the Army Cold Regions Research and Engineering Laboratory and Caterpillar, Inc. and Goodyear Tire and Rubber Co. is looking to develop a numerical model simulating the interaction between tires and deformable surfaces such as thawing and soft soils. This project will integrate the experimental and numerical simulation of tractive loading on deformable terrain with numerical models of tire deformation resulting in a three dimensional finite element simulation of tire-terrain interaction. The expected result of this collaboration is a design tool with the capability to design tires that perform more efficiently on unpaved roads, off-road, and in all-season conditions including snow and thawing soils. In addition, the technology will be used to explore the effects of tire and terrain variables on vehicle performance and terrain damage.

The technology being developed through this CRADA is truly a dual-use technology in that this tool can be applied to the development of commercial as well as military products. In the commercial sector, the use of this tool is expected to greatly improve the efficiency of off-road, mud and snow, and heavy vehicle tires as well as increase construction site productivity by improving vehicle traction resulting in decreased cycle time, fuel costs, tire wear, and time lost due to immobilization, surface damage and repair or reclamation costs. DoD will use this tool to improve tire design and specification, improve performance prediction for off-road vehicles, and provide the capability to predict rutting of and soil damage to unsurfaced roads and to Army training grounds.

### *Ocean Bottom Profiler (OBP) Joint Project (N8)*

The Naval Undersea Warfare Center, Division Newport, (NUWCDIVNPT) and Precision Signal, Inc., (PSI) collaborated to develop state-of-the-art equipment known as the Ocean Bottom Profiler, OBP. The OBP was expected to be capable of producing three-dimensional images of the sub-bottom sea floor mapping the ocean floor in deep and shallow water as well as capable of studying the geomorphology of the bottom by returning information on sediment layers.

With this new vehicle, buried objects in the sea floor can be located and improved data for remote classification of the sea floor can be obtained. PSI and NUWCDIVNPT have worked to develop an array of receivers for electronic near-field beamforming objects in the sediment. Using previously developed acoustic transducer and acoustic baffle technology, a large, low frequency vehicle was constructed at PSI, and test data proved the feasibility of acoustic detection of buried objects in the sea floor.

The Ocean Bottom Profiler program produced the 512 Sonar Vehicle which was first tested and modified at the NUWC laboratory for use in Narragansett Bay. As a result of this testing and calibration, acoustic transducers, receiver arrays, and acoustic baffle materials were incorporated into the 512 design that have made the 512 profiler superior in performance to all bottom profiling vehicles worldwide. Acoustic sediment layers can now be measured in the ocean floor down to a level of 64 meters with a 9 cm resolution.

The 512 Sonar Vehicle is a dual-use development used by many universities, commercial and military users to obtain quantitative and qualitative information on sea floor sediments. The 512 Sonar Vehicle is now manufactured and marketed worldwide by Edge Tech, Inc. under an agreement with PSI. Edge Tech is estimated to be an $8M company with 35 employees. The 512 Sonar Vehicle accounts for about 25% of their business.

### *Detection of Contraband Narcotics by Nuclear Quadrupole Resonance (NQR) (Follow-on CRADA: Fast Recovery Time Nuclear Quadrupole Resonance Detection) (N4)*

The Navy has had a general interest in advanced detection capabilities for narcotics for use with its own forces. In the past this work has been sponsored by DoD and the Defense Advanced Research Projects Agency's (DARPA's) Counterdrug Program.

The objective of the initial CRADA between the Naval Research Laboratory and Quantum Magnetics was to look at using quadrupole resonance to detect heroin hydrochloride and cocaine hydrochloride. The signal, however, was very difficult to see. It was determined that the objectives of this CRADA were too aggressive. Therefore, a second CRADA was initiated to focus on specific advanced circuitry, a rapid recovery receiver, to detect narcotics and explosives. The advanced circuitry studied in this collaboration will be incorporated into a larger commercial system which will result in a better scanner for heroin and cocaine detection than what is currently available.

### *Automated Software for Composite Material Analysis (AF1)*

Modern composite materials are unique in the directional dependence of their strength, stiffness and thermal expansion characteristics and are not amenable to the use of design and analysis procedures employed for conventional isotropic structural materials. The use of modern composites has been steadily increasing and to make the best use of their capabilities, it is extremely important that sophisticated and reliable analysis procedures be established. A number of computer programs and advanced theories for predicting the response characteristics of advanced composite structural materials have been developed and their use continues to grow.

Under a CRADA, Adtech Systems Research and the AFRL/ME were able to develop a fully documented commercial software package, Automated Software for Composite Analysis (ASCA). This software package consists of solution procedures for the efficient analysis of composite materials that are leading to new and innovative avenues for developing optimum designs and establishing new goals.

The number of organizations actively pursuing the development of the use of composite materials is growing. The software package developed under this CRADA is serving the needs of both the Government and private industry. Customers of the package include the aircraft industry (such as Boeing, Lockheed, and United Technologies), composite materials manufacturers, the automobile industry, academia, research organizations, and spacecraft manufacturers.

## Promote Basic Research

### *Formulation of a Liposomal Transdermal Vaccine System and Other Novel Pharmaceuticals (A8)*

The Medical Technology and Practice Patterns Institute, Inc. (MTPPI) and Walter Reed Army Institute of Research teamed together through a CRADA to develop vaccine adjunct technology to devise an effective, safe and easily administered delivery mechanism for vaccination. MTPPI is dedicated to the development and transfer of medical technology through the Vision for World Health Project. MTPPI has identified the need to introduce an alternative vaccine delivery system to reduce the cost and increase the accessibility of vaccination, especially in Third World settings. A liposomal transdermal vaccine system would allow immunization without the need for sterile needles, syringes, and trained personnel, as well as would avoid the complications associated with puncturing the skin.

As a result of this CRADA, a new means of transdermal vaccine delivery was discovered and has advanced the process of bringing needle-free vaccine technology to market. In an article published in Nature magazine,[29] cholera toxin (CT), used to enhance the immune system, was applied to the surface of the skin. When applied, it stimulated an immune response to vaccine components such as diphtheria or tetanus toxoids. This experiment concluded that immunization can be achieved by the simple application of a mixture of CT and vaccine components without penetration or disruption of the skin.

The preclinical research conducted under this CRADA has led to the first clinical trial for a vaccine of particular interest to the Army, E. coli endotoxin technology, for soldiers' diarrhea. The vaccine will be used in field operations. This first FDA-approved Phase I clinical trial has been completed. Phase II and Phase III must now be competed prior to filing a new drug application (NDA), followed by licensing by the FDA. It is anticipated that the Phase II trial will be completed in FY99. For most products, it typically takes 5 to 10 years and an investment of $50 million to $200 million to complete all testing phases, including NDA filing, for licensing by the FDA. For the vaccine being investigated under this CRADA, research has been ongoing for less than two years.

This type of vaccine delivery system also has direct commercial applications to many vaccines such as those being developed for HIV, etc. In addition, to vaccines for human use, it is currently being considered for use on pets.

Two patent applications have been filed on inventions created under this CRADA and a third is in preparation. A major licensing agreement has been executed between WRAIR and MTPPI and sublicensing arrangements with commercial developers and end-users of the technology have begun. This CRADA is on-going with an expiration date of December 31, 2005.

### *Use of Spinning Microfilters to Separate Oil from Water for Abatement of Marine Oil Spills (N10)*

The Marine Spill Response Corporation (MSRC) was a consortium of oil companies, funded by Superfund, whose purpose was to investigate technologies for handling oil spills at sea. A CRADA was developed between the U.S. Naval Surface Warfare Center (NSWC), Carderock Division and MSRC to demonstrate the separation of seawater from oil spill fluids in a wide range of viscosities using non-clogging spinning microfilter oil/water separator technology.

A new concept of separating the oil/water mixture and later disposing of the separated components was explored. A working prototype was developed to prove the concept. The new concept explored under this CRADA has led to the development of a patented process to quickly and effectively separate oil from water with the use of a spinning micro-filter system. NSWC believes that this process may have additional commercial applications.

### *Ocean Bottom Profiler (OBP) Joint Project (N8)*

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In the course of developing the OBP, valuable research was accomplished in the disciplines of acoustics and signal processing, as well as in electronic design, to achieve a multi-channel sub-bottom imaging device which can be incorporated into many applications. As a result of this research, acoustic sediment layers can now be measured in the ocean floor down to a level of 64 meters with a 9 cm resolution.

### *USAF Cooperative Research and Development Agreement Between Weber State University and the Science and Engineering Laboratory (AF8)*

Weber State University (WSU) is a Center for Excellence for Chemical and Materials Analysis which attracts researchers from local private sector businesses. To support various research projects, a CRADA between the Ogden Air Logistics Center, Technology and Industry Support Directorate (OO-ALC/TI) and WSU was developed to provide WSU faculty and staff access to the Air Force Laboratory test instrumentation and/or its science and engineering personnel. Analytical costs associated with these research projects are paid by participating businesses to WSU. In turn, WSU pays the Air Force its normal shop rate for costs incurred in item testing, equipment usage, training, and consultative work for these research projects.

This CRADA established a cooperative association between university academia and Air Force scientists. DoD expertise as well as facilities are shared with the university and the community thus fostering and promoting research between the two partners. The WSU lab personnel and collegiate staff are able to access unique laboratory testing and particular scientific equipment, as well as become involved in consultative evaluations with experienced DoD scientific and engineering personnel. The exchange of test data, consultative sessions and professional personnel interaction has exposed WSU's chemical/materials staff and student population to realistic industrial laboratory education. This cooperative agreement has provided the OO-ALC/TI laboratory personnel with access to collegiate industrial technology, current research, fellowship with professional individuals, and associations with graduate students that may become future DoD scientists, engineers and technicians.

Although this CRADA focuses on promoting basic research, the various research projects undertaken in this collaboration may address other DoD management principles such as warfighting needs, strengthening the industrial base, and reducing cost.

## Assure Quality

### *Advanced Technology for High Resolution Physics Based Interactive Simulation (A1)*

Silicon Graphics, Inc. (SGI) has negotiated CRADAs with CECOM, Night Vision and Electronics Directorate and the U.S. Army Research Laboratory in the area of simulation technology. The NVESD team contributes expertise in sensor simulation, building optimized databases, and immersion techniques. NVESD uses off-the-shelf dedicated equipment to implement sensor simulation and three dimensional noise for special effects. NVESD interest was in pursuing the development of technology to simulate additional sensors and optimize databases associated with them. ARL's interest was in developing a simulation system to provide the appropriate combination of physical models to simulate the effects and interaction of the synthetic environment and the end-user.

The purpose of the agreement with NVESD was to develop an enhanced operational and modeling and simulation capability for individual combatants across three domains of Advanced Concepts and Requirements (ACR), Research, Development and Acquisition (RDA), and Training, Exercises, and Military Operations (TEMO). It was NVESD's objective to support military needs and objectives while fostering development of novel software/hardware for optimized terrain and

sensors with substantial commercial potential to contribute to the economic and military success of the U.S..

The NVESD partnered with SGI because of SGI's reputation as the leading manufacturer of high performance visual and enterprise computing systems. SGI was to provide graphics and computer technology to support the development of high fidelity, interactive synthetic environments for training and operational use.

### *Covert Adjustable Laser Illuminator CRADA (AF2)*

Many Federal and local government entities have a need to positively identify ships and aircraft that are detected by electro-optical sensor systems. This identification must be quick, accurate, and admissible in a court of law. A CRADA between the U.S. Air Force Research Laboratory, Directed Energy Directorate, (AFRL/DE), and FLIR Systems, Inc. (FSI) was established to explore the feasibility, applicability, safety and utility of a fiber coupled diode laser to illuminate an image from a gimbaled assembly. An eye-safety analysis, a positive phenomenology study, and successful ground and airborne field tests were performed.

The integrated system developed in this CRADA enhances FLIR's gimbaled IR sensor system by allowing an area of terrain to be illuminated by a laser and viewed on a screen. The range for this system is approximately 1 km. When used in search and rescue operations, the viewing range can be 5 to 10 km.

The development of an integrated system was derived from the core competencies of both Air Force Research Laboratory and FLIR Systems Inc. While the Air Force's expertise is in the development of fiber coupled diode lasers, FSI's expertise lies in that it is a commercial vendor for products that employ a stabilized Gimbal sensor system with thermal capabilities. This work resulted in transitioning the technology to FSI where they are actively pursuing incorporating the technology into a commercial system. Potential buyers include the U.S. Border Patrol, U.S. Coast Guard, Canadian Government, and German Navy.

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# VI. Three Exemplary CRADAs

## EVALUATION OF ELECTRON CYCLOTRON RESONANCE PLASMA TECHNOLOGY

*Addresses Warfighting Needs, Strengthens the Industrial Base, Promotes Basic Research, and Assures Quality*

Infrared Focal Plane Arrays (IRFPAs) are critical for use as sensors in tanks, helicopters, remotely piloted vehicles, and missiles. IRFPAs are the artificial retinas present in all infrared cameras mounted in these vehicles. These retinas detect thermal radiation and generate real time images of battlefield objects which are warmer or cooler than their surroundings.

A FPA consists of an array of detector cells on a chip. Each cell is an individual sensor pixel. An image is formed by an array in the same way that an image is formed by the charge-coupled device (CCD) in visible cameras. However, unlike CCDs, FPAs operate at infrared wavelengths. IR systems use different types of IR materials in the detector, depending on the level of performance and applications required.[30] The infrared material used in the highest performance IRFPAs, which are sensitive in the 3 - 5 and 8 - 17 micron region of the infrared spectrum, are made of mercury cadmium telluride (HgCdTe), a member of the semiconductor family of materials. An array is synthesized by depositing thin films of HgCdTe onto rigid substrates. These planar layers must be transformed into electrically isolated pixels, the analog of the rods and cones of the human retina. For fifteen years, the industrial baseline process for producing focal pane arrays with mercury cadmium telluride has been to form mesas and trenches in the layers by dipping them into a liquid chemical etchant. All second generation focal plane arrays are manufactured with this technology. To obtain adequate signal to noise ratios for HgCdTe arrays, they must be cooled to temperatures as low as -200°C. The apparatus required for this cooling adds cost and complexity to an IRFPA. At this time, due in part to their cost, the main end user of high performance IRFPAs is the military.

Although the military market is the largest end-user of IR systems, a growing commercial market exists, and is expected to be substantial by the end of the 1990s and into the next century. In 1994, total revenues from U.S. military and commercial consumption were $658.7 million. In 2001, revenues are projected to swell to about $1.45 billion, largely a result of significant increases in commercial applications stemming from new IR materials.[31]

Army requirements for higher standoff distances and target recognition capability have led to concepts for the next generation of arrays which will have a much higher pixel count than is present in the current generation. To keep the cooling requirement at a manageable level, the size of individual pixels will be reduced to minimize the overall size of an array. The largest FPA produced so far is an array of 1,024 pixels by 1,024 pixels, 1024 x 1024 technology is in a very early stage of the development cycle and only a few prototypes this large have been made.

To transform a planar film of HgCdTe into an array of isolated pixels, HgCdTe materials must be etched away from between each pixel and its neighbor. A barrier problem to fabricating larger arrays with smaller pixels is rooted in the isotropic nature of the wet chemical etching procedure which is now used to remove this material. Material is removed as rapidly along the surface of

the wafer as it is in a direction perpendicular to the surface. The widths of trenches are too great for next generation arrays.

In 1993, the U.S. Army Communications and Electronics Research, Development and Engineering Center, Night Vision and Electronic Sensors Directorate, (NVESD) anticipated the need for small feature widths and along with several university and industrial laboratories, made a decision to explore the suitability of a new vapor phase etching process - Electron Cyclotron Resonance (ECR) etching - as a potential replacement for liquid phase etching. The approach would be to insert a masked HgCdTe film into an ECR vacuum system, to expose it to gases such as argon and hydrogen, and to thereby transfer the required pixel pattern through the mask into the HgCdTe by the action of these reactive gases. NVESD purchased a state of the art ECR reactor and initiated an internal program to develop this technology.

Along with NVESD, the Defense Research Projects Agency (DARPA) has dedicated substantial funding to establishing a production capability for common and universal second-generation FPAs. In 1993, DARPA initiated a program known as Flexible Manufacturing whose aim it was to make mercury cadmium telluride focal planes available and affordable to the military. The approach was to develop high yield manufacturing processes for this material. A small ECR etching effort, principally at Loral and at Texas Instruments (TI), was funded under this program.

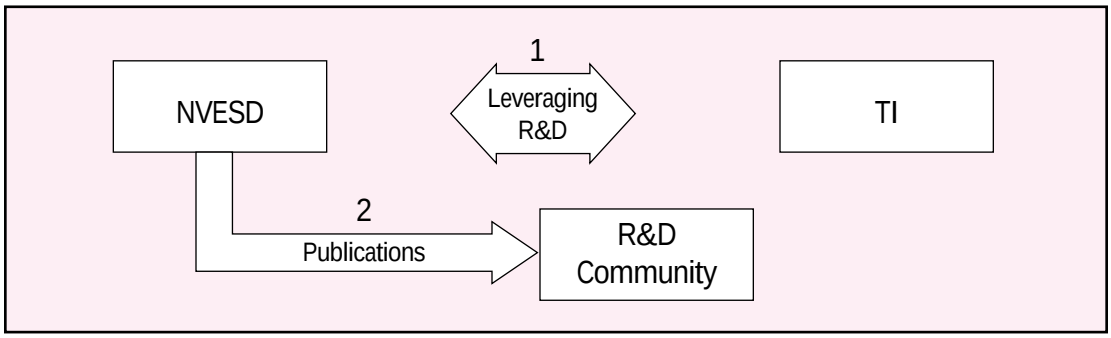
In 1996, TI hired a scientist who had studied plasma etching as a university student and who had published results of great interest to the scientists within NVESD who were involved in the ECR effort. NVESD contacted this scientist to discuss status of ECR programs at TI and at NVESD. It became evident during a series of visits and discussions that each organization had strengths which perfectly complemented those of the other. A CRADA was then negotiated to develop a working relationship to take advantage of these strengths in order to further the development of the next generation of focal plane arrays. In the CRADA it was agreed that TI would contribute the very high quality and many-layered mercury cadmium telluride samples which they routinely make. NVESD would then etch samples of these in its ECR plasma etching apparatus. TI would then measure electrical and structural properties of the etched layers to assess suitability for the TI device architecture.

After one year the etching process looks promising. A few milestones towards developing the next generation FPA have been achieved. The etching process produced an FPA 128 pixels by 128 pixels with each pixel being 24 microns by 24 microns. TI has now purchased a plasma reactor in order to continue the research effort and will eventually integrate this technology into their future production line.

Given that the largest FPA made by existing methods is 1024 pixels by 1024 pixels, more milestones have yet to be met on the road to developing the next generation FPA. Future challenges include:

- Developing a process whereby all electrical characteristics of the HgCdTe film are preserved during etching (at the present time, certain electrical characteristics change);
- Developing a process whereby very small features such as narrow trenches and small-area mesas can be formed by ECR etching;
- Developing a process for making very large focal plane arrays on the order of 2cm x 2cm;
- Developing an ECR process which is carried out under real-time control (an operator would set the final etch depth and an automated control system would take over to monitor the depth and turn off the etching when the target depth had been reached).

This CRADA advanced the knowledge necessary for the future production of next generation focal plane arrays in which the pixels are smaller and closer together. Although no joint research papers have been published at this time, NVESD has published some results of the progress in developing the plasma etching technique. These publications include “An a-Si:H Vacuum Compatible Photoresist Process for Fabricating Device Structures in HgCdTe,” Journal of Electronic Materials, 27 (1998) 689 and “Spectroscopic Ellipsometry study of HgCdTe Epilayer Surfaces During ECR Plasma Etching,” Materials Research Society Symposium Proceedings, 450 (1997) 293.




*CRADA Value Flow Diagram*

## CRADA BETWEEN THE NAVAL TRAINING SYSTEMS CENTER* AND THE COMPUTER GROUP OF MOTOROLA, INC.

*Addresses Warfighter Needs, Reduces Cost and Promotes Basic Research*

*"The CRADA gave us the learning experience to get up to speed on DIS. It gave us the knowledge and the experience to be successful," says Motorola's Ralph Whitney.*

In today's digital age, realistic simulations of complex battlefield scenarios and mission training of large distributed teams are becoming vital in contributing to the superiority enjoyed by the Unites States armed forces. Technology development efforts underlying these simulation capabilities are therefore important to the overall DoD mission.

Distributed Interactive Simulation (DIS) technology provides an infrastructure to build large scale simulations of highly interactive activities by interconnecting several types of simulators via a network. It brings together systems built for separate purposes — technologies from different eras, products from various vendors, and platforms from various services — and permits them to be interoperable in a synthetic, virtual environment. Appropriate protocols, simulation managers and visualization software products are among the many key underlying technological components which make DIS successful. Applications of DIS include distributed mission training, analysis, acquisition, entertainment, education and research.

In FY95 the Naval Air Warfare Center, Training Systems Division (NAWCTSD), and the Computer Group of Motorola, Inc., entered into a CRADA leading to the development of three important DIS tools. The objective of the CRADA was to gain experience with the new DIS interoperability standard through jointly developing software to support networking of simulators using DIS. The knowledge-share CRADA ended in FY97. About one man year of effort over a three year period was input from the government while Motorola contributed staff and expertise.

Three products resulted from this CRADA partnership: Middleman, Aladdin and Daemon. The development of these products was a by-product of the original intent that was to gain experience with the interoperability standard. The development of each of these software products was a unique, one-of-a-kind effort. Since Motorola does not hold intellectual property rights to the software, these products are available to government agencies and their contractors free of charge. The software can be briefly described as follows:

- Middle Man is a DIS simulation manager whose job it is to automatically and dynamically initialize and control DIS exercises.
- Aladdin is a DIS Stealth Viewer that allows the user to attach to any entity (such as a boa or a tank) in a DIS exercise and view the entity from any orientation. It provides several view modes and visual control mechanisms.
- Daemon is a DIS Network Interface Unit. The DIS Daemon is being used on a number of DIS programs ensuring stability and reliability under real world conditions. It helps in providing flexible and scalable architecture for DIS applications.

This CRADA effort allowed the NAWCTSD to leverage Motorola's software development expertise and Motorola to further their knowledge in military simulations. In addition, the experience has also allowed NAWCTSD staff to function as a "smart buyer" whereby their research team is up to date with the technology, thus allowing for more educated purchases.

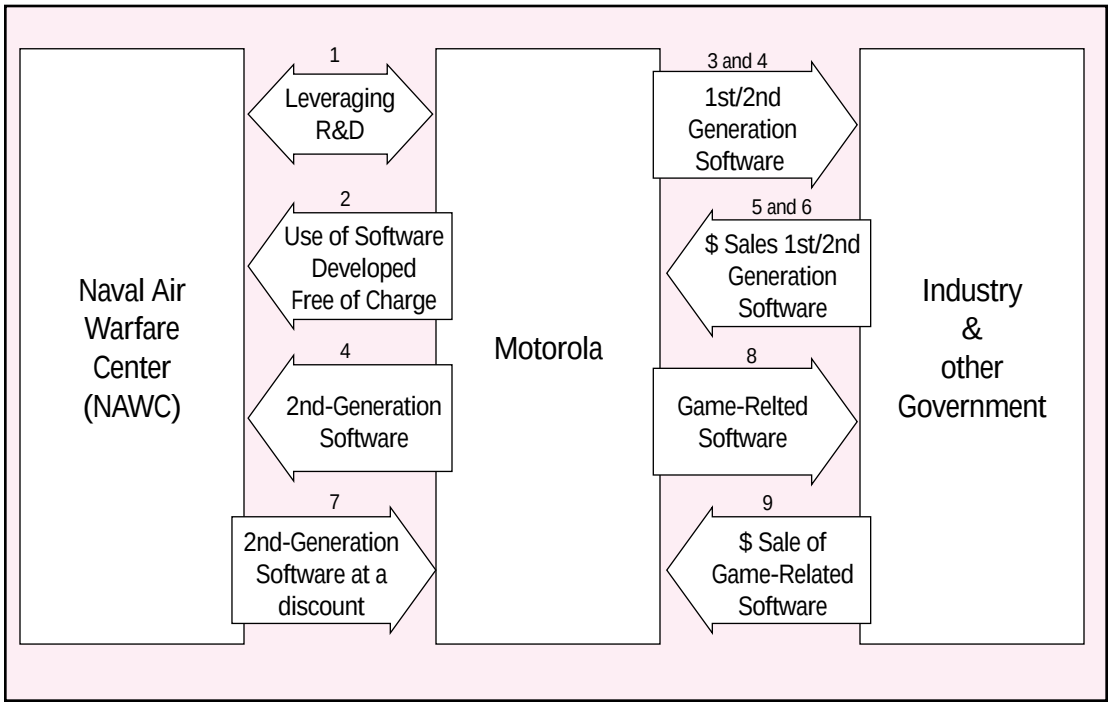
**Now known as the Naval Air Warfare Center, Training Systems Division*

The two partners jointly demonstrated the DIS technology at the annual IITSEC (Inter-Service Industry Training Systems and Education Conference) show, which is one of the biggest shows in the training and simulation area.

DIS technology is used by many DoD agencies, including the Naval Research Laboratory, the U.S. Army Soldier Systems Command, and the Night Vision and Electronics Sensors Directorate. One application of its use is the annual ULCHI FOCUS exercise in Korea, which is an annual large-scale mission training exercise. The DIS tools developed in the CRADA are also embedded in the electronic warfare LAN access unit of the Battleforce Tactical Trainer (NAVSEA).

This CRADA provided the springboard for Motorola to enter the DIS-related software market. Motorola has internally developed a second-generation software called MODIAS that is indirectly linked to the work performed under the CRADA. The second-generation products are available to the government at a 40 percent discount.

Motorola is distributing the three DIS developed software tools at no charge and making a profit by providing the support services to these products. The commercial application for DIS is in the gaming industry. The sales of the software associated with the gaming industry applications are estimated to be $1M.




*CRADA Value Flow Diagram*

## HAZARDOUS MATERIALS MANAGEMENT SYSTEM

*Reduces Cost and Strengthens the Industrial Base*


The U.S. Air Force Research Laboratory, Materials and Manufacturing Directorate (AFRL/ML), uses more than 10,000 different chemicals in over 40,000 containers in its 15 facilities. This level of activity and complexity necessitates a very aggressive pollution prevention program to assure that health and safety are a top priority and that environmental issues are correctly managed.

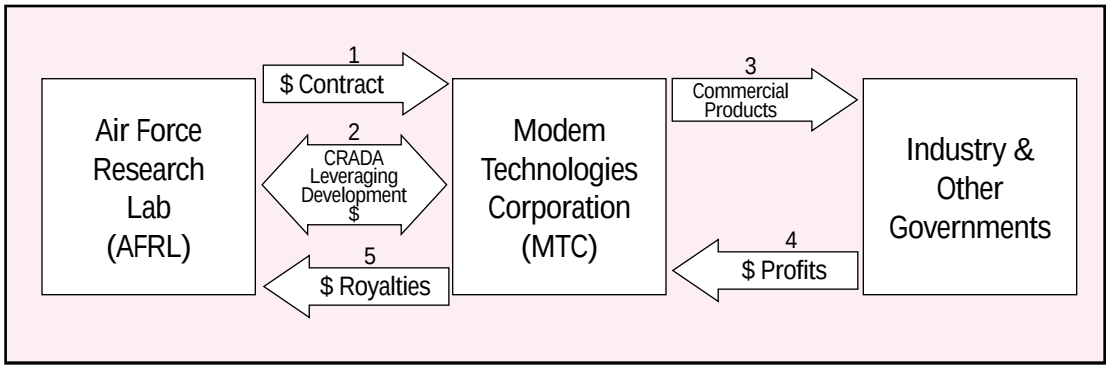
In an effort spearheaded by the Assistant Chief of Integration and Operations Division, AFRL and driven by new environmental regulations for strict regulatory compliance, the AFRL/ML in cooperation with Modern Technologies Corporation, worked together through a contract to develop a software system using bar code technology to coordinate the tracking and control of hazardous materials. With the intention to commercialize the system, a CRADA was then negotiated to use the AFRL/ML, then Wright Laboratory, as a Beta test site for the computerized environmental management system.

In conducting the Beta test at the Directorate, over 40,000 hazardous materials and waste containers were tracked throughout their complete use life, resulting in purging of over 10,000 hazardous material containers no longer needed by researchers. More than 400 containers of unknown materials were identified, classified and eliminated. In some cases, the effort permitted the identification of replacement chemicals that are less harmful to the environment.

As a result of the feedback received from the Beta test site, the industrial partner was able to further develop and commercialize the software system. The original version, the Integrated Materials Management System (IMMS), now commercially known as the LINDEN™ Environmental Management System (LINDEN™) is a Microsoft Windows™ application on a single PC or PC network. LINDEN™ enables effective centralized hazardous materials management, waste minimization and pollution prevention, reduction in materials costs, and prevention of materials shortages through more effective control and retrieval. The system has the capability to flag and report expired or unstable materials and storage of incompatible hazard classes. On-Line access to full-text Materials Safety Data Sheets allows users immediate access to information on the hazards of a material or product. LINDEN™ can produce environmental reporting to satisfy the requirements of SARA Title III, including Tier I and Tier II reports, as well as emissions summary reports to assist with completion of the Toxic Release Inventory (Form R) report and Clean Air Act Title V reporting. The Hazardous Waste Manifest and Land Ban Module, a component of the now upgraded LINDEN™ system, provides manifest generation and tracking, land disposal restriction notification, and annual/biennial reporting. The LINDEN™ system contains a tremendous amount of pre-loaded data needed for all facilities to develop data for special reports that can be influential in identifying pollution and waste minimization opportunities. This data includes: U.S. DoT tables, U.S. EPA List of Lists, SARA storage conditions and container types, and crucial information for over 74,000 CAS chemicals. Using system data, the storage of hazardous chemicals is consolidated, helping to eliminate duplicate and excess stock.

The development and use of the LINDEN™ system has truly been a success in reducing costs and preventing potential fines associated with the strict hazardous materials regulatory compliance initiatives. The value in using the LINDEN™ system to reliably manage the hazardous materials program at the AFRL/ML is conservatively estimated by the Air Force to be $10K in terms of equivalent contracting costs. By incorporating the LINDEN™ system, the AFRL has saved significant materials and waste disposal costs as well as labor hours that would have typically been spent on documentation and tracking. The LINDEN™ system was at the core of the AFRL, Materials Directorate, winning the 1995 Ohio's Governor's Award for Outstanding Achievement in Pollution Prevention.

In keeping with the intent of the technology transfer law, this CRADA produced a commercialized product that was transferred into the marketplace and is now available for both government and industry use. More recently, Modern Technologies has produced a more advanced upgraded system with additional functionality and a web interface. Now that the software has been upgraded, the AFRL is no longer eligible for royalties. However, Modern Technologies Corporations sells the enhanced LINDEN™ system at a discount to government agencies. At least $100K in software has been installed at government installations such as the Center for Disease Prevention and Control, Atlanta, GA and the Army Redstone Arsenal in Huntsville, AL. The LINDEN™ system has also been sold to aerospace and manufacturing industries, such as Delta Airlines and Cincinnati Milacron, where the Air Force received $4K in royalties.




*CRADA Value Flow Diagram*

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# VII. Summary

The purpose of this study was to evaluate a sampling of DoD CRADAs to assess the benefits that the DoD is reaping from participating in these agreements. Legislation has focused on the transfer of technology from the federal laboratories to the private sector, however, value has also been realized by the federal partners involved.

The DoD S&T management principles, as outlined in the DoD, DDR&E Science and Technology Strategy, guide the laboratories in meeting the needs of the DoD mission. In the future, linking the CRADAs to the management principles, can also serve as a way to assess the value they are providing to the DoD mission.

The intent of Congress has remained essentially the same for many years: leveraging federal R&D dollars for the greater good of the national economy. The expectation has been that more partnerships between industry and Federal labs would improve U.S. competitiveness, help small businesses, and create new jobs and products for the nation's economy. This expectation needs to be managed, for although some believe that CRADAs should lead to commercial products, in actuality this appears to be the exception rather than the rule.

The CRADA is a technology transfer mechanism which allows flexibility in R&D and protects the intellectual property of parties. CRADAs typically entail knowledge-share opportunities that involve small advances in research that lead to product or process improvements, advance research to points that would have taken longer to achieve independently, or allow an opportunity to perform research that would not have otherwise occurred due to restricted resources.

In times of constrained R&D budgets, whether it be a small business, a large business or a DoD laboratory, both parties and the private sector can benefit from leveraging expertise that lies outside of their own labs in areas of mutual interest. Drawing upon external expertise can provide the means to overcome obstacles that arise along the path to new discoveries or even determine that the path being pursued is leading to a dead-end and another needs to be followed. New knowledge can lead to advancing the research to the next level in the development cycle or can spawn new ideas leading to new R&D programs altogether. The following is a summary of the findings resulting from this study.

*Generalized Findings*

- CRADAs are seen by many Labs as mission extenders
- CRADAs can provide a means for industry to talk openly with Government
- CRADAs are a means of advancing research to points that would otherwise have taken longer to achieve independently
- CRADAs can provide access to Government/Military facilities that are not otherwise commercially available
- CRADAs can result in new, improved, or more cost effective products/processes
- CRADAs can eliminate interpersonal barriers that can arise in a contractual relationship
- CRADAs are successful when objectives are clearly laid out
- CRADAs can advance research for both partners sometimes leading to new programs/contracts
- CRADAs that result in follow-on CRADAs between organizations is an indicator of progress

In supporting the belief that successful CRADAs should lead to commercial products, many of the CRADAs evaluated in this study resulted in products or product improvements. Some of the products are either still in development or pending commercialization, however, they are at stages where they are considered to be viable products. In some cases, the use of DoD facilities or test sites provided a means for products to be further refined as a result of the data gathered by the industry partner.

This evaluation also showed that by pooling resources through the use of a CRADA, DoD as well as the industry partner can stretch their limited R&D dollars resulting in larger research efforts than either party could fund independently. The values for work-in-kind and cash-in contributed by the industry partners is an indication of the value industry associates with partnering with the Government via the CRADA. The actual dollars that are coming into the laboratories cover such costs as overhead, materials, third party contracts, and travel expenses.

During the course of the study, some interesting insights were discovered. In most cases, the Office of Research and Technology Assistance, ORTA, is not the first point of entry for an industrial partner wishing to do business with the DoD. CRADAs are typically initiated through working relationships that have evolved between scientists over the years through research conferences, consortia, contracts, etc. In some cases the industrial partner or government scientist initiates a literature search to find those people working in a specific area of interest. This finding underscores the need for S&Es to know how to use this mechanism.

It was interesting to note that the scientists and engineers are not as aware as they could be of the technology transfer process that exist at the laboratories. Additional training in technology transfer processes and what they can do for the S&E could exploit the use of the mechanisms making technology transfer more effective.

In reviewing the selection of CRADAs, it became apparent that CRADAs do not take a simple linear route to commercialization and may only serve as one step along the route. Each partnership is unique in its process to meet its objectives. Some CRADA partnerships are a continuation of an earlier contractual partnership for the purposes of bringing a technology into the commercial sector. Some CRADAs lead to a patentable product or process bringing dollars back to the laboratory. Some CRADAs leverage R&D dollars and make small advances in a specific technological area which over time (and maybe many CRADAs later), may lead to a product or process which the DoD can access.

# Appendices

# Army CRADAs

| | | Address Warfighting Needs | Reduce Cost | Strengthen the Industrial Base | Promote Basic Research | Assure Quality |
|---|---|---|---|---|---|---|
| A1 | Advanced Technology for High Resolution Physics Based Interactive Simulations | ● | ● | | ● | ● |
| A2 | Blanket CRADA Between Ford, General Motors, Chrysler and the U.S. Army Tank-Automotive Research, Development and Engineering Group | | | | ● | |
| A3 | Construction Equipment Performance Optimization | | | ● | ● | ● |
| A4 | CORE-LOC Concrete Armor Unit | | | ● | ● | |
| A5 | Development of Biodegradable Polymers | | | ● | ● | |
| A6 | Development of Novel Imaging System for Medical, Non-Destructive Testing & Investigation of Micro-electronic Circuits | | | ● | ● | |
| A7 | Evaluation of Electron Cyclotron Resonance Plasma Technology | ● | | ● | ● | ● |
| A8 | Formulation of a Liposomal Transdermal Vaccine System and Other Novel Pharmaceuticals | ● | | ● | ● | ● |
| A9 | Full Scale Fabrication & Optimization of Composite Cylinder Processing | | ● | ● | ● | |
| A10 | Vaccines for Infectious Desease | ● | | ● | | ● |

## A1

*Title: Advanced Technology for High Resolution Physics Based Interactive Simulation*

*Federal Partner: U.S. Army Communications and Electronics Command, Night Vision and Electronic Sensors Directorate, (NVESD)*

*Federal POC: Max Lorenzo*

*Non-Federal Partner: Silicon Graphics, Inc., (SGI)*

*Non-Federal POC: Bob Paddison and Judith Pafford*

*Status: Open*

*Summary:*

SGI negotiated CRADAs with CECOM, Night Vision and Electronic Sensors Directorate and the U.S. Army Research Laboratory in the area of simulation technology.

NVESD's team has expertise in sensor simulation, building optimized databases, and immersion techniques. NVESD uses off-the-shelf dedicated equipment to implement sensor simulation and three dimensional noise for special effects. NVESD interest was in pursuing the development of technology to simulate additional sensors and optimize databases associated with them.

ARL's interest was in developing a simulation system to provide the appropriate combination of physical models to simulate the effects and interaction of the synthetic environment and the end-user.

The purpose of this agreement with NVESD was to develop an enhanced operational and modeling and simulation capability for individual combatants across three domains of Advanced Concepts and Requirements (ACR), Research, Development and Acquisition (RDA), and Training, Exercises, and Military operations (TEMO). It was NVESD's objective to support military needs and objectives while fostering development of novel software/hardware for optimized terrain and sensors with substantial commercial potential to ensure economic military success of the U.S.

There has been some general collaboration and sharing of information between engineers, such as synthetic environmental terrain data. SGI hosted the NVESD POC at its simulation laboratory where he worked to optimize his application. There were a number of retirements and resignations of people involved with this CRADA on both sides which, in addition to the lack of specific objectives, resulted in less than optimal accomplishments.

### Value/Benefits to DoD:

*Supports DoD Management Principle: Address Warfighting Needs*

One goal of this CRADA is to provide enhanced simulation capabilities for individual combatants. Simulations allow technologies to be evaluated by the user in the context of their particular functionality providing a thorough evaluation of concepts early in the technology development cycle.

*Supports DoD Management Principle: Reduce Cost*

This CRADA focuses on the use of simulation instead of field data and testing resulting in substantial cost reductions.

*Supports DoD Management Principle: Promote Basic Research*

The intent of this CRADA was to share information from both sides. General collaboration and information sharing on synthetic environmental terrain data occurred between engineers.

*Supports DoD Management Principle: Assure Quality*

The Night Vision and Electronic Sensors Directorate partnered with SGI because of SGI's reputation as the leading manufacturer of high performance visual and enterprise computing

systems. SGI's was to provide graphics and computer technology to support the development of high fidelity, interactive synthetic environments for training and operational use.

## Benefits to Non-Federal Partner:

The interaction among partners in this CRADA will provide SGI with information to make refinements to existing hardware and software products and enhancements to designs of future products that will make them more useful to their customers and end-users.

A2

*Title: Blanket CRADA Between Ford, General Motors, and Chrysler and the U.S. Army Tank-Automotive Research Development and Engineering Center (TARDEC)*

*Federal Partner: U.S. Army Tank-Automotive Research, Development, and Engineering Center*

*Federal POC: Doug Miller*

*Non-Federal Partner: Ford Motor Company, Chrysler and General Motors*

*Status: Open*

*Summary:*

The Big Three auto makers jointly signed this "Blanket" CRADA (also referred to as "Master" or "Umbrella" CRADA). Unlike most CRADAs this blanket CRADA set a precedent by fast-tracking all future R&D between the auto makers and the Army. It uses established language agreed to by all parties. When any one of the Big Three wishes to enter into a CRADA all that is needed is a 2-3 page statement-of-work. This agreement allows the Big Three to streamline the labor intensive CRADA process from several months to just a few days saving administrative costs on all sides.

One research effort performed under this CRADA was the use of TARDEC's Visualization Laboratory by General Motors. General Motors funded 100 test subjects to use their Visualization Laboratory. The Visualization Laboratory is a facility designed to simulate tank-development technology in a virtual-reality setting created by an on-site super computer network. The Army uses the facility to test tank designs under simulated battlefield conditions prior to developing costly prototypes. General Motors used the laboratory to gain information on visual perception at intersections, in bad weather conditions, blind spots, and on the impact of different vehicle colors and outdoor light on drivers. General Motors used this data for design and redesign of vehicles. General Motors also provided their data to the Army.

The blanket concept has worked well for these partners because both industry and government had similar technical interests and the industries were located in close proximity to each other. Before this CRADA was established there was little interaction between the auto industry and the Army despite similar needs.

Although the intent of this CRADA is to promote basic research, individual projects pursued under this agreement may support other DoD S&T management principles.

## Value/Benefits to DoD:

*Supports DoD Management Principle: Promote Basic Research*

The sharing of data and equipment from experiments, such as from the Visualization Laboratory Research, will advance research for both the Army and the auto industry given the similarities that exist between two.

## Benefits to Non-Federal Partner:

General Motors was able to leverage its resources by utilizing TARDEC's Visualization Laboratory. One new application arising from General Motor's research in the Visualization Laboratory was the addition of a third brake light to the Cadillac STS making it more perceptible to other drivers.

## Other Benefits:

This Blanket CRADA is unique in that it facilitated a complex strategic partnership between the Army and multiple industrial partners.

A3

*Title: Construction Equipment Performance Optimization*

*Federal Partner: U.S. Army Cold Regions Research and Engineering Laboratory*

*Federal POC: Sally Shoop*

*Non-Federal Partner: Caterpillar, Inc. Peoria, IL and Goodyear Tire and Rubber Co., Akron, OH*

*Non-Federal POC: Paul Corcoran, Caterpillar, Inc and Mike Trinko, Goodyear Tire and Rubber Co.*

*Status: Open*

*An example of the types of tire-terrain interactions being modeled*

*Summary:*

Current tire models do not consider the interaction of the tire with deformable media such as soil or snow, focusing only on interactions with pavements. The goal of this CRADA is to develop a numerical model simulating the interaction between tires and deformable surfaces such as thawing and soft soils. This project will integrate the experimental and numerical simulation of tractive loading on deformable terrain with numerical models of tire deformation resulting in a three dimensional finite element simulation of tire-terrain interaction. The expected result of this collaboration is a design tool with the capability to design tires that perform more efficiently on unpaved roads, off-road, and in all-season conditions including snow and thawing soils. In addition, the technology will be used to explore the effects of tire and terrain variables on vehicle performance and terrain damage.

## Value/Benefits to DoD:

*Supports DoD Management Principle: Strengthen the Industrial Base*

The technology being developed in this CRADA is truly a dual-use technology in that this tool can be applied to the development of commercial as well as military products. In the commercial sector, the use of this tool will greatly improve the efficiency of off-road, mud and snow, and heavy vehicle tires, increase construction site productivity by improving vehicle traction, and therefore decrease cycle time, fuel costs, tire wear, and time lost due to immobilization, surface damage and repair or reclamation costs. DoD will use this tool to improve tire design and specification, improve performance prediction for off-road vehicles and provide the capability to predict rutting of and soil damage to unsurfaced roads and Army training grounds.

*Supports DoD Management Principle: Promote Basic Research*

This CRADA will further DoD and Corps of Engineers efforts in the development of Army mobility models, virtual prototyping of vehicles, and virtual proving ground concepts as well as providing a capability to predict rutting of and soil damage to unsurfaced roads and Army training areas.

*Supports DoD Management Principle: Assure Quality*

The work being performed under this CRADA is highly proprietary and has generated a great deal of interest within the technical community. The development of this tool will put the two non-federal partners ahead of their competition while at the same time having direct military applications.

## Benefits to Non-Federal Partner:

The benefit to Caterpillar will be improved tire performance on earth moving and mining equipment based on the use of the design tool in their design process. The benefits to Goodyear will be the application of a new process within their design and development process which will further product improvements.

## Other Benefits:

The development of this CRADA between the three parties has broken down barriers and has allowed for free-flowing conversations and technical exchange.

A4

*Title: CORE-LOC Concrete Armor Unit*

*Federal Partner: U.S. Army Engineers' Waterways Experiment Station, (WES)*

*Federal POC: Jeff Melby and Phil Stewart*

*Non-Federal Partner: A. R. Wijnberg, South Africa*

*Status: Open*

*Summary:*

Engineers at WES developed CORE-LOC, an innovative coastal protection armor unit. CORE-LOC has several advantages over its competitors. A CORE-LOC armor layer has outstanding interlocking features and is extraordinarily efficient, dissipating the maximum amount of wave energy with the least amount of concrete, therefore requiring significantly less material than existing armor units. It also has a reserve stability that other structures don't have.

The objective of this CRADA was to gain the acceptance of new armor units by the coastal engineering community which is normally a very slow process. The cost of failure is typically so large that few are willing to risk trying new technology.

This CRADA allowed WES engineers to work with design engineers at A. R. Wijnberg in the model testing and prototype construction of the world's first breakwater built with CORE-LOC concrete armor units. The assistance provided by WES engineers was critical to the proper model testing of the CORE-LOC structure, as it was to the placement of CORE-LOCs on the prototype structure. A. R. Wijnberg was willing to recommend CORE-LOC for this breakwater and work with WES engineers to successfully conduct model tests and actually construct the breakwater at Port Saint Francis, South Africa.

A product commercialization that is application specific was achieved. Wijnberg's faith in the Corps of Engineers' product for protection for a peninsula and breakwater provided an early opportunity to field test the new armor unit.

## Value/Benefits to DoD:

*Supports DoD Management Principle: Strengthen the Industrial Base*

Although the Army Corps of Engineers is unique to DoD in that it services both civilian and military needs, CORE-LOC is a good example of a dual-use technology resulting from research that serves both the civilian and military sectors. Knowledge gained in wave prediction phenomena was applied in the development of CORE-LOC which is used in civilian breakwater applications.

*Supports DoD Management Principle: Promote Basic Research*

Each time WES works with an engineering firm to provide a specific design for a particular application of CORE-LOC, knowledge is gained that can be applied to future designs. WES developed the technology and continues to develop it.

## Benefits to Non-Federal Partner:

The non-federal partner was able to successfully construct the breakwater at Port Saint Francis, South Africa.

## Other Benefits:

The early support for CORE-LOC has developed into an active foreign market. Money in the form of both royalties and reimbursable studies is helping to leverage WES' R&D funding.

This project greatly strengthened WES' negotiating position in licensing the CORE-LOC concrete armor unit. With projected royalties of $2.00 to $5.00 per metric ton, a single half-mile long breakwater built with 12 ton armor units could result in royalties of over $1/2-million. Each

CORE-LOC unit weighs about 2 tons requiring these units to be built on site. Therefore, patent applications have been filed in over 40 countries and trademark applications filed in many others. The CORE-LOC concrete armor unit is now licensed to four companies, each having an assigned geographic territory. These territories include Europe and South America, North America, Japan, and South Africa. In the near future, annual royalties could easily exceed $1 million.

## A5

*Title: Development of Biodegradable Polymers*

*Federal Partner: U.S. Army Natick Research, Development and Engineering Center*

*Federal POC: Dr. Jo Ann Ratto*

*Non-Federal Partner: Zeneca (Imperial Chemical Industries (ICI) Americas, Inc.)*

*Status: Closed*

*Biodegradable cup and bag coated with Biopol polymer*

*Summary:*

The objective of this CRADA was to investigate the feasibility of utilizing Zeneca's bacterial polyester, which is produced in a patented process, as water resistant, biodegradable coatings on paper and starched-based film. It was hoped to develop a biodegradable coating for paper to replace polyethylene, which is not biodegradable.

Zeneca has patented an innovative fermentation process whereby biodegradable polymers are produced from corn and other agricultural feedstock. The microorganism, alcaligenes eutrophus, which occurs widely in soil and water, converts the carbohydrate (glucose) in the feedstock to resin. By the end of the fermentation process, the microorganisms accumulate up to 80% of their dry weight as resin. The process harvests the resin by breaking open the cells and extracting and purifying the polymer. Various other organisms in the environment also consume the resin as a source of carbon.

Sold under the trade name "Biopol," the polymers have many of the properties of traditional plastics, but can be processed by conventional techniques. They are stable, durable, and moisture-resistant. The Biopol cup is a paper cup coated with a biodegradable plastic developed for the Navy. The technology involves plastic extrusion processing to coat the paper from which the cups are formed. The cups were tested to meet the military specifications and were tested for biodegradation in the marine environment.

This effort was funded by the Navy for compliance with the MARPOL Treaty, which is the Marine Pollution Treaty.

### Value/Benefits to DoD:

*Supports DoD Management Principle: Strengthen the Industrial Base*

The work performed under this CRADA in developing a biodegradable coating for paper to replace polyethylene has military and non-military applications for use in biodegradable utensils, cups, trays, bags, meat wrappings, etc.

*Supports DoD Management Principle: Promote Basic Research*

This CRADA supported knowledge-share in a number of ways. Zeneca supplied samples of biodegradable materials and information on processing and blending of the materials onto starch-based and cellulose materials. Natick and Zeneca cooperated in formulating new compatible blends and laminates of biodegradable plastic. Natick formed the materials into commercially usable items and fully characterized the mechanical and physical compatibility of these items with current operational activities, current storage stability requirements, and with handling and disposal requirements both in the field and on board ship. Natick also conducted biodegradability assays in simulated and actual marine and soil environments, respirometry testing and nutritional availability studies with these materials.

## Benefits to Non-Federal Partner:

This CRADA partnership has provided Zeneca with the opportunity to run full-scale production of the Biopol material. Material from these production runs were manufactured, by another vendor, into 500,000 Biopol cups.

A6

*Title: Development of Novel Imaging System for Medical, Non-Destructive Testing and Investigation of Microelectronic Circuits*

*Federal Partner: U.S. Army Communications and Electronics Research, Development and Engineering Center, Night Vision and Electronic Sensors Directorate (NVESD)*

*Federal POC: Conrad Terrell*

*Non-Federal Partner: Marvin E. Lasser, Inc.*

*Non-Federal POC: Marvin Lasser*

*Status: Closed*

*Summary:*

CECOM has sponsored the development of uncooled thermal imaging since 1979. In January of 1991, this work was declassified. The uncooled technology differs from the traditional thermal imaging systems in that the detector array is operated at or near ambient room temperature, rather than at a cryogenic temperature. A one-stage thermoelectric stabilizer is used to control the detector array temperature, to keep the operating point near a detector material ferroelectric phase transition.

The objective of this CRADA was to investigate the possibility of exploiting uncooled thermal imaging technological developments for ultrasonic imaging applications utilizing the piezoelectric, rather than the ferroelectric, properties of one particular uncooled detector material. These ultrasonic imaging applications include medical diagnosis and non-destructive testing of devices such as microelectronic circuits.

In medical imaging, a 2-dimensional ultrasonic focal plane array would be used for spatial display of anatomical structures allowing a relatively inexpensive diagnosis, in many cases without requiring a surgical procedure. A probe, similar to a computer mouse, is placed on the body and rotated over the area of interest. Ultrasonic waves are transmitted into the area under investigation, reflect back to the probe, and are then transduced by the focal plane array with the resulting images displayed on a computer monitor for analysis. One particular disadvantage associated with ultrasonic imaging is the fuzziness of the images, making interpretation somewhat difficult. Other disadvantages relate to equipment size and cost.

Marvin E. Lasser, Inc., is focusing on improvements to ultrasonic imaging medical diagnostic instrumentation, in particular, higher performance and lower cost ultrasonic imaging instrumentation. Ultrasonics permits doctors to examine patients for small differences in tissue composition. The technique is especially useful in diagnosing cancer in body parts such as breasts, testicles, the thyroid and the appendix.

Initial discussions between CECOM and Lasser centered upon adapting Texas Instrument's (TI) uncooled focal plane array for the ultrasonic imaging application. The TI focal plane array was made from Barium Strontium Titanate (BST) material. Since BST is a piezoelectric as well as a ferroelectric material, it was thought that it could serve as an ultrasonic as well as an infrared transducer. Technical discussions on the proposed idea at TI showed a lack of interest on TI's part, partly because TI believed that BST was not a good piezoelectric material and partly because the TI uncooled infrared thermal imaging readout chip was too complex to be adapted to such a different application.

Lasser has subsequently found interest in the idea at LORAL Infrared Imaging Systems (LIRIS), another company with expertise in developing readout integrated circuits for uncooled thermal imaging systems. Technical discussions between Lasser and LIRIS, arranged by NVESD, resulted in a working relationship between the two companies which led to the development of a functional 128 X 128 element ultrasonic imaging array.

In the five years since the inception of the CRADA between NVESD and Lasser, Lasser has continued the development of a commercially viable ultrasonic imaging system.

## Value/Benefits to DoD:

*Supports DoD Management Principle: Strengthen the Industrial Base:*

The work in this CRADA focused on uncooled focal plane arrays, one of the current long-term investment initiatives for DoD. It is anticipated that alternate commercial applications for infrared imaging technology would benefit DoD by sharing in the development costs.

*Supports DoD Management Principle: Promote Basic Research:*

Knowledge was advanced in using uncooled focal plane arrays for ultrasonic imaging applications.

## Benefits to Non-Federal Partner:

The non-federal partner enriched his knowledge in using ultrasonic imaging in medical diagnostic instrumentation. Additional work resulted in a CRADA with ARL in the same technology area and an SBIR with the Air Force.

A7

*Title: Evaluation of Electron Cyclotron Resonance Plasma Technology*

*Federal Partner: U.S. Army Communications and Electronics Research, Development and Engineering Center, Night Vision and Electronic Sensors Directorate, (NVSED)*

*Federal POC: Jack Dinan*

*Non-Federal Partner: Texas Instruments, (TI) (now Raytheon)*

*Non-Federal POC: Robert Keller*

*Status: Open*

*Summary:*

The artificial retina in all high performance focal plane arrays which are sensitive in the 8 - 17 micron region of the infrared spectrum is made of mercury cadmium telluride, a member of the semiconductor family of materials. The retina is synthesized by depositing thin films of mercury cadmium telluride onto rigid substrates. These planar layers must be transformed into electrically isolated pixels - the analog of the rods and cones of the human retina. For fifteen years, the industrial baseline process for doing so has been to form mesas and trenches in the layers by dipping them into a liquid etchant. All second generation focal plane arrays are manufactured with this technology. Army requirements for higher standoff distances and target recognition capability have led to concepts for a next generation of arrays whose pixels will be considerably smaller and more closely spaced then those for currently available arrays. A barrier to fabricating these smaller features is rooted in the isotropic nature of wet chemical etching. Material is removed as rapidly along the surface of the wafer as it is in a direction perpendicular to the surface. The widths of trenches are too great for next generation arrays.

During the early part of this decade, Texas Instruments Inc. (TI) was one of the three premier suppliers of first generation infrared systems to the military. To meet second generation requirements, TI had chosen a device architecture which was unique and which required precise control over trench widths and depths. Manufacturing yield at TI for second generation focal plane arrays was low, due in part to the need to wet etch.

In 1993, NVESD anticipated the need for small feature widths and along with several university and industrial laboratories, made a decision to explore the suitability of a new vapor phase etching process as a potential replacement for liquid phase etching.

In 1996, TI hired a scientist who had studied plasma etching as a university student and who had published his results. NVESD contacted this scientist and invited him for a visit. It became evident during a series of visits and discussions that each organization had strengths which perfectly complemented each other. A CRADA was then negotiated to develop a working relationship to take advantage of the strengths each organization had in the technology area of infrared focal plane arrays in order to further the development of the next generation focal plane array.

In the CRADA it was agreed that TI would contribute the very high quality and many-layered mercury cadmium telluride samples which they routinely make. NVESD would then etch these samples in its electron cyclotron resonance plasma etching apparatus. TI would then measure electrical and structural properties of the etched layers to assess suitability for the TI device architecture.

TI has now purchased a plasma reactor identical to the one at NVESD in order to continue the research effort, eventually they hope to integrate this technology into their production line.

## Value/Benefits to DoD:

*Supports DoD Management Principle: Address Warfighting Needs*

The Army is very interested in focal plane arrays for use as sensors in tanks, helicopters and some missiles. These sensors act as an artificial retina and detect thermal radiation. They are used in heat seeking missiles where they can hone in on a target that is warmer than its surroundings. They are also used in night vision navigation applications where again they can sense a target from its thermal radiation.

*Supports DoD Management Principle: Strengthen the Industrial Base*

Work in the area of focal plane arrays is one of the current DoD long-term investment initiatives in technology maturation. Under this CRADA, a new process is being developed that may be integral to the manufacturing of next generation focal plane arrays for use in both military and commercial products.

*Supports DoD Management Principle: Promote Basic Research*

After one year, the etching process looks promising. A few milestones towards developing the next generation FPA have been achieved. Certain features of arrays etched with a plasma were exploited to give a robust manufacturing process. The etching process produced a FPA 128 pixels by 128 pixel with each pixel being 24 microns by 24 microns. This CRADA advanced the knowledge necessary for the future production of next generation focal plane arrays in which the pixels are smaller and closer together.

*Supports DoD Management Principle: Assure Quality*

This CRADA was developed to take advantage of the strengths each organization had in the technology area of infrared focal plane arrays in order to further the development of the next generation focal plane array.

## Benefits to Non-Federal Partner:

TI benefited from being able to work with the plasma etching process before purchasing an identical piece of processing equipment to that which they were using at the government site. TI is one of four or five companies that sells infrared focal plane arrays to the government for night vision applications. This new process, once perfected, will be used in manufacturing military products.

## Other Benefits:

NVESD scientists and those from E-OIR Measurements (on-site collaborators), have filed a patent disclosure based on these new uses for plasma etching. The concept, which was disclosed, is not identical to the technology developed by NVESD/TI, but the ideas generated during this collaboration led directly to this disclosure.

Although no joint research papers have been published at this time, NVESD has published some results of the progress in developing the plasma etching technique. These publications include “An a-Si:H Vacuum Compatible Photoresist Process for Fabricating Device Structures in HgCdTe,” Journal of Electronic Materials, 27 (1998) 689 and “Spectroscopic Ellipsometry Study of HgCdTe Epilayer Surfaces. During ECR Plasma Etching,” Materials Research Society Symposium Proceedings, 450 (1997) 293.

A8

*Title: Formulation of a Liposomal Transdermal Vaccine System and Other Novel Pharmaceuticals*

*Federal Partner: Walter Reed Army Institute of Research (WRAIR)*

*Federal POC: Dr. Carl Alving*

*Non-Federal Partner: Medical Technology and Practice Patterns Institute, Inc. (MTPPI)*

*Non-Federal POC: Dennis Cotter, MTPPI and Dean Lewis, Iomai*

*Status: Open*

*Summary:*

The Medical Technology and Practice Patterns Institute, Inc. is dedicated to the development and transfer of medical technology through the Vision for World Health Project. MTPPI has identified the need to introduce an alternative vaccine delivery system to reduce the cost and increase the accessibility of vaccination, especially in Third World settings. A transdermal vaccine delivery system fulfills this objective and is appropriate to the charters and goals of both WRAIR and MTPPI.

A liposomal transdermal vaccine system would allow immunization without the need for sterile needles, syringes, and trained personnel, as well as would avoid the complications associated with puncturing the skin. The goal of this CRADA is to develop vaccine adjunct technology to devise an effective, safe and easily administered delivery mechanism for vaccination.

As a result of this CRADA a new means of transdermal vaccine delivery was discovered. An article on the technology has been published in Nature magazine. Two patent applications have been filed on inventions created under this CRADA and a third is in preparation. A major licensing agreement has been executed between WRAIR and MTPPI and sublicensing arrangements with commercial developers and end-users of the technology have begun. Substantial resources (revenues and professional scientific staff) have come into WRAIR under this CRADA with MTPPI.

Gregory M. Glenn, Mangala Rao, Gary R. Matyas, and Carl R. Alving, “Skin Immunization Made Possible by Cholera Toxin,” Nature, Vol. 391, No. 6670, 851, February, 26, 1998.

## Value/Benefits to DoD:

*Supports DoD Management Principle: Address Warfighting Needs*

The first trial to be conducted under this CRADA was for a vaccine of particular interest to the Army, E. coli endotoxin technology, for soldiers diarrhea. The vaccine will be used in field operations.

*Supports DoD Management Principle: Strength the Industrial Base*

The research conducted under this CRADA has advanced the process of bringing needle-free vaccine technology to market. The skin patch vaccines developed under this CRADA will have direct commercial applications. This type of vaccine delivery system has applications to many vaccines such as those being developed for HIV, etc. In addition to vaccines for human use, it is currently being considered for use on pets.

*Supports DoD Management Principle: Promote Basic Research*

The preclinical research conducted under this CRADA has led to the first clinical trial for a vaccine for E. coli endotoxin technology. This first FDA-approved Phase I clinical trial has been completed. Phase II and Phase III must now be competed prior to filing a new drug application (NDA), followed by licensing by the FDA. It is anticipated that the Phase II trial will be completed in FY99. For most products, it typically takes 5 to 10 years and an investment of $50 million to $200 million to complete all testing phases, including NDA filing, for licensing by the

FDA. For the vaccine being investigated under this CRADA, research has been ongoing for less than two years.

*Supports DoD Management Principle: Assure Quality*

MTPPI's use of the WRAIR laboratory space as well as MTPPI conducting the human trials at the WRAIR allowed core competencies in military relevant technologies to be maintained.

Benefits to Non-Federal Partner:

A major licensing agreement has been executed between WRAIR and MTPPI and sublicensing arrangements with commercial developers and end-users of the technology have begun.

A9

*Title: Full Scale Fabrication & Optimization of Composite Cylinder Processing*

*Federal Partner: U.S. Army Research Laboratory*

*Federal POC: Dana Granville*

*Non-Federal Partner: Composite Development Corporation (CDC)*

*Status: Closed*

*Summary:*

ARL entered into this CRADA to investigate a new way to make constant-cross-section, high performance composite products. CDC, a subsidiary of Fiberspar and Tube Corporation, one of the nation's largest producers of carbon fiber tubing with a major market share of windsurfing masts, booms, and bases. CDC believed that composite materials could help make a superior hockey stick, but it did not have the capital to invest in an assembly line to test the idea. CDC then approached ARL for their expertise in polymer composite design and testing. Under the CRADA, CDC used ARL's state-of-the-art equipment to test a manufacturing technique called pultrusion, where fibers spooled at one end are continuously drawn through a resin bath and then pulled into a heated die, where they are cured. The cured material is then pulled from the die in a continuous form for cutting into any desired length, such as the four feet necessary for a hockey stick.

This CRADA looked at evaluating different resin systems using the pultrusion technique. CDC was particularly interested in epoxy/urethanes and acrylic/epoxy formulations.

## Value/Benefits to DoD:

*Supports DoD Management Principle: Reduce Cost*

The lessons learned from this collaborative effort will help the Army to produce constant-cross-section profile items such as helicopter stringers and stiffening elements at a lower finished cost per pound.

*Supports DoD Management Principle: Strengthen the Industrial Base*

The research conducted under this CRADA has led to advances in manufacturing techniques for stronger, lighter and more durable materials whether it be for low-cost launch tubes, helicopter rotor blades, bridge decks, tent poles or hockey sticks.

*Supports DoD Management Principle: Promote Basic Research*

This working partnership allowed ARL to further its research in pultrusion manufacturing techniques which can produce stronger, lighter, and more durable materials more quickly and at lower costs. Each party learned a considerable amount about how tougher, hybridized resins can be processed successfully at low viscosities with pultrusion, as well as improved methods of "feeding" glass and carbon fiber into pultrusion die "on-the-fly."

## Benefits to Non-Federal Partner:

CDC was able to use Army experts and equipment in an experimental processing program to manufacture and test a new world-class product without a large investment in equipment.

## A10

*Title: Vaccines for Infectious Diseases*

*Federal Partner: Walter Reed Army Institute of Research*

*Federal POC: Dr. Ken Eckles*

*Non-Federal Partner: Ora Vax, Inc.*

*Non-Federal POC: Tom Monas*

*Status: Open*

*Summary:*

There have been and continue to be a number of efforts being pursued under this CRADA in the area of vaccine development. The work focuses on vaccine production of product that is producible for use in Phase I and Phase II clinical trials. WRAIR has the controlled facilities required for this type of production. Ora Vax's focus is to work on the manufacturing and commercialization aspects of vaccines and is assisting in the QC/QA manufacturing capability at WRAIR.

The initial work under this CRADA was to develop a new vaccine technology for E. coli protection that would be packaged in biodegradable polymers and taken orally. As the polymers dissolve, antigens are released to stimulate immunity. Polymers comprising the microcapsule can be specifically formulated for a "time release" over days or months. The objective of this technology was to eliminate the need for multiple injections of vaccines. Returning to a clinic for multiple shots is a problem in developing countries, remote areas and military operations. The stabilizing effect of microencapsulation also allows vaccines to be shipped and stored without refrigeration which is important in tropical areas of the world where it is difficult to preserve a vaccine. However, after a market assessment, the work on the E. coli vaccine was dropped from Ora Vax's product portfolio.

Under this CRADA, Ora Vax is currently working with WRAIR on the manufacturing of a vaccine for peptic ulcers that can lead to stomach cancer. A market analysis indicated that this vaccine would be a $1B/year opportunity.

This CRADA was also amended to address an additional product, a Japanese encephalitis vaccine.

### Value/Benefits to DoD:

*Supports DoD Management Principle: Address Warfighting Needs*

The vaccines being studied under this CRADA will support the general health of the soldier. The objective of the microencapsulated diarrheal vaccine was to give this vaccine to soldiers just before deployment providing months of E. coli protection.

*Supports DoD Management Principle: Strengthen the Industrial Base*

The vaccines being developed under this CRADA have dual-use applications. In addition to protecting soldiers, an E. coli vaccine would protect approximately 28 million people (8 million from the U.S.) who travel to developing countries each year.

*Supports DoD Management Principle: Assure Quality*

In this CRADA, Ora Vax provides resources and revenue to support the WRAIR in mission critical technology areas.

### Benefits to Non-Federal Partner:

Ora Vax is able to use the WRAIR controlled laboratory facilities to produce a product usable in Phase I and Phase II clinical trials. Ora Vax can then use the data to get FDA approval to conduct further trials.

# Navy CRADAs

| | | Address Warfighting Needs | Reduce Cost | Strengthen the Industrial Base | Promote Basic Research | Assure Quality |
|---|---|---|---|---|---|---|
| N1 | CRADA between The Naval Training System Center and Computer Group of Motorola, Inc. | ● | ● | | ● | |
| N2 | Deep-Towed Acoustic/Geophysical System | ● | | | ● | |
| N3 | Demonstration of CL-20 Based Explosive Formulations | ● | | ● | | |
| N4 | Detection of Contraband and Narcotics by Nuclear Quadrupole Resonance (NQR)/Fast Recovery Time Nuclear Quadrupole Resonance Detection | | | ● | ● | |
| N5 | Electric Vehicle/Hybrid Electric Vehicle Battery Chemistry Research & Evaluation | | | | ● | |
| N6 | Exploring the Effects of Lipid-Lowering Agents on Complex Cognitive and Performance Tests | ● | | | | |
| N7 | New Paint Formulations for Fluorinated Polyurethane Resins | | ● | ● | | |
| N8 | Ocean Bottom Profiler (OBP) Joint Project | ● | | ● | ● | |
| N9 | Technical Assistance to CIT | | | ● | ● | |
| N10 | Use of Spinning Microfilters to Separate Oil from Water for Abatement of Marine Spills | | | | ● | |

## N1

*Title: CRADA Between The Naval Training Systems Center* and Computer Group of Motorola, Inc.*

*Federal Partner: Naval Air Warfare Center, Training Systems Division (NAWCTSD)*

*Federal POC: David Kotick*

*Non-Federal Partner: Motorola, Inc.*

*Non-Federal POC: Ralph Whitney*

*Status: Closed*

*Summary:*

The Distributed Interactive Simulation (DIS) interoperability standard provides a protocol for formatting messages that enable simulators to communicate with each other. The interfacing of simulators is highly desirable in the synthetic battlefield.

The objective of this CRADA was to gain experience with the new DIS interoperability standard through jointly developing software to support networking of simulators using distributed interactive simulation.

The three products resulting from this collaboration are: Middle Man, Aladdin and Daemon. The development of these products was a by-product of the original intent which was to gain experience with the interoperability standard. Since Motorola does not hold intellectual property rights, these products are available to government agencies and their contractors free of charge.

### Value/Benefits to DoD:

*Supports DoD Management Principle: Address Warfighting Needs*

The tools developed under this CRADA include a stealth viewer which enables the warfighter to view the synthetic battlefield from different perspectives including a "god's eye view." The software developed under this CRADA was used in several other programs including Army and Air Force programs.

*Supports DoD Management Principle: Reduce Cost*

By co-developing the software with Motorola, the overall costs to the Government associated with the development of the software was reduced. Simulations, such as the ones developed under this CRADA, allow technologists and warfighters to collaborate earlier in the development process thereby providing users the means for a more thorough evaluation of concepts which leads to substantial cost reductions.

** Now known as the Naval Air Warfare Center, Training System Division*

*Supports DoD Management Principle: Promote Basic Research*

Experience was gained in working with the new interoperability standard which led to the development of several products. Armed with a new working knowledge in DIS, NAWCTSD can now act in a "Smart Buyer" mode thereby making more educated purchases.

## Benefits to Non-Federal Partner:

This CRADA provided the springboard for Motorola to enter the DIS-related software market. Motorola has developed second generation software that is indirectly linked to the work performed under the CRADA. These second generation products are available to the Government at a 40% discount.

## N2

*Title: Deep-Towed Acoustic/Geophysical System*

*Federal Partner: Naval Research Laboratory*

*Federal POC: Joseph Gettrust*

*Non-Federal Partner: Seafloor Sciences International*

*Non-Federal POC: Donald Hussong*

*Status: Open*

*Summary:*

The objective of this CRADA was to improve the state-of-the-art Deep-Towed Acoustic Geophysic System (DTAGS) and the Seafloor International developed Integrated Short Base Line (ISBL) navigation systems through research. The parties were to determine whether coupling the DTAGS with the ISBL would improve the geographical accuracy of NRL's seismic seafloor data interpretation. The joint research was also to evaluate whether the ISBL is suitable for deep ocean applications. The goal of the research was to improve the knowledge of seafloor environmental features for Naval operations.

NRL and Seafloor Sciences jointly refurbished a Navy system. Seafloor Sciences added specialized navigation capabilities to the system that they had learned through their pipeline survey work. The system was then used in an experimental survey in conjunction with JAPEX (a consortium of petroleum research experts). Vertical profiles of the ocean floor were produced. These types of profiles are used in oil and gas exploration. Information on geoacoustic properties of seafloor sediments was obtained which is important in addressing seafloor stability.

In addition to labor hours, Seafloor Sciences also paid the third party costs associated with some of the system's refurbishing efforts. The Navy received data and charts from the Japan survey.

### Value/Benefits to DoD:

*Supports DoD Management Principle: Address Warfighting Needs*

Geoacoustic properties are important to the Anti-Submarine Warfighter operations in determining the propagation of sound in a navigation environment through the water. It can determine the range at which one is able to detect a target actively or passively. Knowledge of geoacoustic properties can provide a tactical advantage to the warfighter.

*Supports DoD Management Principle: Promote Basic Research*

NRL scientists teamed with industrial scientists to improve laboratory instruments and achieve types of data that otherwise would not have been attained.

### Benefits to Non-Federal Partner:

Seafloor Sciences is a survey company that sells geotechnical information to other companies. They are interested in commercializing applications in Deep-Towed Seismic Systems. They are trying to stimulate enough interest in this instrument to warrant commercialization.

N3

*Title: Demonstration of CL-20 Based Explosive Formulations*

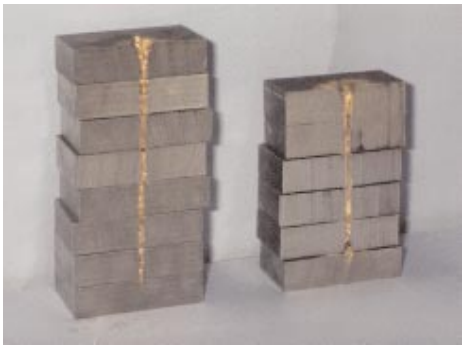
*Federal Partner: Naval Air Warfare Center Weapons Division, China Lake*

*Federal POC: Tom Boggs*

*Non-Federal Partner: Thiokol Corporation*

*Non-Federal POC: Charles Zisette*

*Status: Open*



*CL-20 (left) penetrated 7 one-inch steel plates while PBXN-5 (right) penetrated only 5*

*Summary:*

The objective of this CRADA between the Naval Air Warfare Center Weapons Division (NAWCWPNS), China Lake and Thiokol Corporation is to develop and demonstrate the performance of high quality explosive fill for warheads with the ultimate goal of testing a warhead containing CL-20 based explosive that demonstrates performance significantly above that of existing explosives. Data is being gathered to demonstrate the advantages of CL-20 in weapons applications. Thiokol has the capability to make the quantities required for weapon demonstration. China Lake will build and test the weapons to demonstrate their capabilities.

Dr. Arnold Nielson, a chemist who has since retired from NAWCWPNS, first synthesized the unique cyclic citramine energetic chemical compound CL-20 in 1987. It was soon realized that CL-20 had greater energy output than existing (in-use) energetic materials while having the same acceptable level of insensitivity to shock and other external stimuli. Further, CL-20-based formulations were clean burning, with reduced signature and also met requirements spawned by the Government's emphasis of its role in preserving the natural environment. The CL-20 chemical compound was recently issued as a Navy patent (Patent No. 5,693,794) on December 2, 1997.

The interest in CL-20-based propellants and explosives lies with their flexibility in making trade-offs between requirements. For example, CL-20-based propellants can be produced having high performance, reasonable hazards, low plume signature, and with clean exhaust products.

NAWCWPNS has continued to characterize and refine the CL-20 molecule, while Thiokol has been working on the CL-20 molecule produced from their own processes. Thiokol in conjunction with NAWCWPNS scaled-up its process to the point where it could produce 1,000-plus pound batches of the material. While there have been other new energetic materials developed over the years, none have been successfully scaled-up to mass production levels. A new Navy Manufacturing Technology Program to scale up the CL-20 production process is planned for FY99 that will include NAWCWPNS, Naval Surface Warfare Center Indianhead Division, and Thiokol.

## Value/Benefits to DoD:

*Supports DoD Management Principle: Address Warfighting Needs*

CL-20 has greater energy output than existing (in-use) energetic ingredients while having an acceptable level of insensitivity to shock and other external stimuli which meets the Navy's criteria for development of "insensitive munitions," capable of withstanding unplanned exposure to external forces. It is hoped that a warhead containing a CL-20-based explosive will demonstrate performance significantly above that of existing explosives.

*Supports DoD Management Principle: Strengthen the Industrial Base*

The successful completion of this CRADA will demonstrate the potential for CL-20. Therefore, it is hoped that the demand for the material will increase. With increased demand and improved production processes for high-grade product, availability will increase leading to a lower cost for the ingredient. CL-20 is a dual-use material and should find wide application in commercial as well as military markets, thus reducing the production cost for military use.

## Benefits to Non-Federal Partner:

The ability of Thiokol to scale-up its manufacturing process has made them the only manufacturing source for CL-20. Thiokol plans to use the data being gathered to demonstrate the advantages of CL-20 which will hopefully lead to business from other sources including the commercial marketplace. Thiokol also plans to market the Navy to see if there is interest in developing a warhead program that will use this material in their explosive. Thiokol has also been marketing the basic ingredient as well as end-product formulations for explosives, gun propellants and, to a lesser degree, rocket propellants

## N4

*Title: Detection of Contraband Narcotics by Nuclear Quadrupole Resonance (NQR) (Follow-on CRADA: Fast Recovery Time Nuclear Quadrupole Resonance Detection)*

*Federal Partner: Naval Research Laboratory*

*Federal POC: Dr. Al Garroway*

*Non-Federal Partner: Quantum Magnetics (owned by Invision)*

*Non-Federal POC: Dr. Lowell Burnett*

*Status: Closed*

*Summary:*

The Navy has had a general interest in advanced detection capabilities for narcotics for use with its own forces. In the past this work has been sponsored by DoD and the Defense Advanced Research Projects Agency 's (DARPA's) Counterdrug Program.

The objective of the initial CRADA between the Naval Research Laboratory and Quantum Magnetics was to look at using quadrupole resonance to detect heroin hydrochloride and cocaine hydrochloride. The signal, however, was very difficult to see. It was determined that the objectives of this CRADA were too aggressive. Therefore, a second CRADA was initiated to focus on specific advanced circuitry, a rapid recovery receiver, to detect narcotics and explosives. NRL has evaluated the circuitry and has given the data to Quantum Magnetics. NRL will keep the circuit for two years for laboratory use.

### Value/Benefits to DoD:

*Supports DoD Management Principle: Strengthen the Industrial Base*

The advanced circuitry studied in this CRADA will be incorporated into a larger commercial system, "Qscann," which will result in a better scanner than what is currently available.

*Supports DoD Management Principle: Promote Basic Research*

Working in partnership streamlined the advancement of knowledge in the applications of quadrupole resonance for explosive and narcotics detection.

### Benefits to Non-Federal Partner:

The non-federal partner hopes to commercialize the advanced detection technology. The potential customer base for this type of detection equipment includes US Customs, airports, airlines, and embassies.

## N5

*Title: Electric Vehicle/Hybrid Electric Vehicle Battery Chemistry Research and Evaluation*

*Federal Partner: Naval Surface Warfare Center, Crane Division*

*Federal POC: Jim Gucinski*

*Non-Federal Partner: AdvanceTek*

*Non-Federal POC: Ellen Engleman*

*Status: Open*

*Summary:*

AdvanceTek is an Indiana not-for-profit organization. Electrocore, a partnership of the Naval Surface Warfare Center, Crane Division, AdvanceTek, Purdue University and Indiana University was established by AdvanceTek to advance research and development of Electric and Hybrid Electric Vehicle (EV/HEV) technologies. Electrocore developed a Battery Evaluation and Testing Center (BETC) to provide testing evaluation services to the EV/HEV industry for all power systems.

The objective of the CRADA with AdvanceTek was to determine a means to measure the propulsion capacity of batteries to provide the passenger of an electric vehicle with information on how far the car can travel before recharging of the battery is necessary. Working to meet this objective, the partnership is currently working to develop an algorithm for adaptive State-of-Change and State-of-Health systems for hybrid and electric vehicle battery pack applications.

### Value/Benefits to DoD:

*Supports DoD Management Principle: Promote Basic Research*

The partners involved in this CRADA are advancing basic research in methods of measuring the usable energy capacity in batteries. A better understanding of vehicular battery technologies will lead to more effectively utilizing batteries for DoD applications. This new knowledge may also lead to the effective use of batteries as a propulsion mechanism for electric vehicles which is of interest to both the automobile and electric power generation industries.

### Benefits to Non-Federal Partner:

The research conducted under this CRADA will provide AdvanceTek with a basic understanding of battery technology which will promote long-term developments in the electric vehicle and hybrid electric vehicle technologies.

## N6

*Title: Exploring the Effects of Lipid-Lowering Agents on Complex Cognitive and Performance Tests*

*Federal Partner: Naval Medical Research Institute*

*Federal POC: LCDR Eric Bower, MD*

*Non-Federal Partner: Bristol-Myers Squibb*

*Non-Federal POC: Dr. Joan Stagger*

*Status: Closed*

*Summary:*

Elevated serum cholesterol remains a significant risk factor in the development of coronary artery disease (CAD). Primary prevention of myocardial infarction with HMG-CoA reductase inhibitors has been well documented, and extends the potential use of these agents into a much larger population. A recent report raised the possibility of central nervous system effects from the use of this class of medication. Given the increasing potential that younger, active duty aviators could be placed on this class of medication for primary prevention of CAD, it became necessary to evaluate members of this class for possible cognitive side effects.

The objective of this CRADA was to investigate the effects of two cholesterol-lowering medications (pravastatin and lovastatin) on cognitive performance. No significant adverse effects were observed from study participants. Baseline cognitive testing showed no difference between groups and no difference from published norms. Cognitive testing following drug administration showed no difference between placebo and either treatment group, and no difference from baseline testing. Pravastatin and lovastatin had no measurable effect on cognitive performance as measured by a computerized neuropsychologic test battery. The ability to complete a standardized clinical pharmacology trial in an active duty population while maintaining flight status has been demonstrated.

"Lack of Measurable Effect of HMG-CoA Reductase Inhibitors on Cognitive Performance," E.A. Bower, R.N. Baney, P.M. Holmes, S. Biggerstaff, K. Selby, and T.B. Calvit, Naval Aerospace Medical Research Laboratory & Naval Operational Medicine Institute, Pensacola, FL, presented at the Aerospace Medical Association's Annual Meeting, May 1998, Seattle.

### Value/Benefits to DoD:

*Supports DoD Management Principle: Address Warfighting Needs*

As a result of this CRADA, flight surgeons now have additional medications in their formulary that can be used to safely treat aviators with elevated cholesterol levels, and potentially prevent first time myocardial infarctions in this population.

### Benefits to Non-Federal Partner:

Through the writing and presentation of the findings, the safe use of the drugs for pilots will be publicized without making a change in the use of the medication. Given that the military aviation community has much stricter standards for health and safety than the civilian community, the implication is that if the medication is approved for use in military airmen the average pilot would feel more comfortable using the medication. The study resulted in an approved drug for use in military aircrew, from which Bristol-Myers Squibb gained an expanded market by extension.

### Other Benefits:

The Navy was able to receive vital information on the effects of these medications on cognitive performance which was used in recommendations to the Bureau of Medicine and Surgery. Recommendations based on the results of the study provided information for use of the drug on a new population.

## N7

*Title: New Paint Formulations for Fluorinated Polyurethane Resins*

*Federal Partner: Naval Research Laboratory*

*Federal POC: Dr. Robert Brady*

*Non-Federal Partner: 21st Century Coatings, Inc.*

*Non-Federal POC: Grover Howard and Gene Lindsey*

*Status: Closed*

*Summary:*

The Navy was using a fluorinated polyurethane paint as a top coat for their Navy Facilities Engineering Command, Navy Facilities Guide Specification 09872 four-coat paint system used to coat the inside of petroleum storage tanks. This top coat cost $750.00 per gallon. 21st Century licensed the technology for the fluorinated polyurethane from the Navy and combined it with technology from other patents and developed a three-coat variant paint system called WC5, Navy Facilities Guide Specification 09970.

21st Century tested this new paint system at the Naval Research Laboratory paint shop facility. The WC5 is a highly fluorinated coating that is very stable and hydrophobic as well as UV resistant, flexible and chip resistant. The top coat used in WC5 costs $180.00 per gallon. WC5 is now used on Navy petroleum storage tanks as well as those of the Army Corps of Engineers.

### Value/Benefits to DoD:

*Supports DoD Management Principle: Reduce Cost**

In going from a four-coat paint system (wash primer coat, zinc-rich urethane coat, urethane manufacturing coat and fluorinated top coat) to a three-coat paint system (two epoxy coats and a highly fluorinated top coat) incorporating the less expensive top coat can save in both labor and material costs. As an example of the cost savings, coating a tank 40 feet in diameter by 35 feet in height with the old system would cost approximately $29,714.00 compared to the same tank coated with the WC5 system which would cost approximately $12,952.00. The savings just in the application costs in going from a four-coat process to a three-coat process is $2,827.44.

*Supports DoD Management Principle: Strengthen the Industrial Base*

By establishing a commercial source for the fluorinated polyurethane resin used in the WC5 paint system, the Navy can buy it from the commercial source more cheaply than the earlier Navy-approved paint system. The Army Corps of Engineers as well as others in the commercial sector use this paint system on petroleum storage tanks as well as on other welded steel products.

### Benefits to Non-Federal Partner:

21st Century Coatings benefits from brokering the resin product to paint manufacturers.

### Other Benefits:

The Naval Research Laboratory receives royalties from the Patent License Agreement for the resin material as laid out in the CRADA.

*Calculations for a tank 40ft in diameter by 35ft in height:

Surface area of 5,654.88 $ft^2$ (not including internal top structures)
Application costs of .50/$ft^2$

Four-Coat System:
Wash primer coat @$9.00/gallon and coverage of 300 $ft^2$/gallon
Zinc-rich urethane coat @ $20.00/gallon and coverage of 380 $ft^2$/gallon
Urethane manufacturing coat @ $43.00/gallon and coverage of 250 $ft^2$/gallon
Fluorinated top coat @ $750.00/gallon and coverage of 250 $ft^2$/gallon

WC5 Three-Coat System:
Epoxy coat #1 @$21.00/gallon and coverage of 220 $ft^2$/gallon
Epoxy coat #2 @$21.00/gallon and coverage of 220 $ft^2$/gallon
Fluorinated top coat @ $180.00/gallon and a coverage of 300 $ft^2$/gallon

## N8

*Title: Ocean Bottom Profiler (OBP) Joint Project*

*Federal Partner: Naval Undersea Warfare Center, Newport Division, (NUWCDIVNPT)*

*Federal POC: Ken Walsh*

*Non-Federal Partner: Precision Signal, Inc., (PSI)*

*Non-Federal POC: Dr. Lester LeBlanc*

*Status: Closed*

*Summary:*

In this CRADA, NUWCDIVNPT and PSI collaborated to develop state-of-the-art equipment known as the Ocean Bottom Profiler, OBP. The OBP was to be capable of mapping the ocean floor in deep and shallow water as well as be able to study the geomorphology of the bottom by returning information on sediment layers.

The Ocean Bottom Profiler program produced the 512 Sonar Vehicle which was first tested and modified at the NUWCDIVNPT laboratory for use in Narragansett Bay. As a result of this testing and calibration, acoustic transducers, receiver arrays, and acoustic baffle materials were incorporated into the 512 design that have made the 512 profiler superior in performance to all bottom profiling vehicles worldwide.

Under this CRADA, NUWCDIVNPT and PSI have worked to develop a more complex Ocean Bottom Profiler that is capable of producing three-dimensional images of the sub-bottom sea floor. With this new vehicle, buried objects in the sea floor can be located and improved data for remote classification of the sea floor can be obtained. PSI and NUWCDIVNPT have worked to develop an array of receivers for electronic near-field beamforming objects in the sediment. Using previously developed acoustic transducer and acoustic baffle technology, a large, low frequency vehicle was constructed at PSI, and test data proved the feasibility of acoustic detection of buried objects in the sea floor. Acoustic sediment layers can now be measured in the ocean floor down to a level of 64 meters with a 9 cm resolution. Today new, smaller, high frequency design of this vehicle is under development for use on Autonomous Underwater Vehicles (AUVs) to survey sea floor sediments and locate buried objects in remote shallow water locations.

Diane Medeiros, "Development of a Sonar System for Ocean Bottom Profiler," Third Joint Meeting of the Acoustical Society of America and the Acoustical Society of Japan, Honolulu, HI, 2-6 December 1996.

### Value/Benefits to DoD:

*Supports DoD Management Principle: Address Warfighting Needs*

The results of these efforts significantly contributed to the design of the AN/WSQ-9 Sonar System, a NUWCDIVNPT initiative that will soon provide significant new warfighting capabilities in mine detection to the U.S. Submarine Fleet. The first installation of this capacity into a U.S. submarine is planned for FY99.

*Supports DoD Management Principle: Strengthen the Industrial Base*

The 512 Sonar Vehicle is a dual-use development used by many universities, commercial and military users to obtain quantitative and qualitative information on sea floor sediments. The 512 Sonar Vehicle is now manufactured and marketed worldwide by Edge Tech, Inc. under an agreement with PSI.

*Supports DoD Management Principle: Promote Basic Research*

In the course of developing the OBP, valuable research was accomplished in the disciplines of acoustics and signal processing, as well as in electronic design, to achieve a multi-channel sub-bottom imaging device which could be incorporated into several different applications.

## Benefits to Non-Federal Partner:

PSI developed the 512 Sonar Vehicle for commercial use in mapping and classification of sea floor sediments and marketed worldwide by Edge Tech, Inc. under an agreement with PSI.

PSI designed an "in-hull" version of the OBP to be used on large vessels for both shallow and deep water applications. A system was installed on the RV Endeaver by PSI and used by Naval Research Laboratory (NRL) to survey sea floor sediments in coastal North Atlantic waters. The data from these surveys were used by NRL to develop a sea floor classification model using Biot theory. The program was successful and, as a result, the OBP is being considered for use in the U.S. Navy.

## Other Benefits:

In addition to the contribution to the AN/WSQ-9, the Government received several valuable by-products of the OBP research. These include detailed sub-bottom profiles of the area of Narragansett bay in the vicinity of Gould Island, a suite of computer programs for wave-form design, and refinement of techniques that can be used to find buried mines, perform bottom surveying support of amphibious operations, perform bottom feature navigation for submarines and unmanned underwater vehicles in shallow water operations, and characterize the ice cap structure from below.

## N9

*Title: Technical Assistance to CIT*

*Federal Partner: Naval Surface Warfare Center, Dahlgren Division (NSWCDD)*

*Federal POC: Ramsey Johnson*

*Non-Federal Partner: Virginia Center for Innovative Technology, (CIT)*

*Non-Federal POC: Dr. Eilene Heveron, CIT and Dr. Ed Veazey, S.E. Ventures, Inc.*

*Status: Closed*

*The Sea Alert Hat*

*Summary:*

The Office of Naval Research had given their laboratories between $3K and $5K for technical assistance to small businesses. With this funding, NSWCDD generated this CRADA with Virginia Center for Innovative Technology (CIT) with the idea to transfer technology from NSWCDD to those companies in the Commonwealth of Virginia that through the CIT have requested such technology. It was expected that technology in the fields of Devices and Sensors, Information and Systems Sciences, Advanced Data Processing Methods, Pulsed Power Technology, Simulation and Modeling, and Electromagnetic Environmental Effects would be of the most interest for cooperative research.

During the terms of the agreement with CIT only one company, S.E. Ventures, requested technical assistance and was interested in radiography range assistance. This small business was developing apparatus to assist stranded mariners. The life saving tools called Sea and Ski Alert hold the promise of locating lost and stranded persons by making them more visible to searching radar and afford new ways of hoisting strobe lights and flares. The CRADA was developed to tests these products on the NSWCDD River Range. The tests focused on the products' reliability at different radar ranges and, preliminarily, resulted in favorable performance.

## Value/Benefits to DoD:

*Supports DoD Management Principle: Strengthen the Industrial Base*

One goal of this particular CRADA was to strengthened technology transfer through encouraging the sharing of facilities and equipment and providing technical assistance for small business in the Commonwealth of Virginia. However, depending on what type of assistance was needed, as outlined in the statement-of-work, determined whether the results contributed to strengthening the industrial base. In this particular case where there was only one effort pursued under this CRADA. The effort indeed contributed to strengthening the industrial base through the commercialization of the Sea and Ski Alert devices.

*Supports DoD Management Principle: Promote Basic Research*

The objective of this CRADA was to promote partnerships between small businesses in the Commonwealth of Virginia and the Naval Surface Warfare Center, Dahlgren Division to advance technology through facility sharing and providing technical assistance to those who sought it. This assistance led to the conquering of technical hurdles and advancing research.

## Benefits to Non-Federal Partner:

This CRADA provides a means for small businesses to team with a DoD laboratory to overcome technical roadblocks related to the advancement of their technology.

## N10

*Title: Use of Spinning Microfilters to Separate Oil from Water for Abatement of Marine Oil Spills*

*Federal Partner: US Naval Surface Warfare Center (NSWC), Carderock Division*

*Federal POC: Dr. E. Fischer*

*Non-Federal Partner: Marine Spill Response Corporation (MSRC)*

*Status: Closed*

*Summary:*

The Marine Spill Response Corporation (MSRC) was a consortium of oil companies, funded by Superfund, whose purpose was to investigate technologies for handling oil spills at sea. After an initial briefing by NWSC to MSRC on NSWC capabilities, a CRADA was developed to demonstrate the separation of seawater from oil spill fluids in a wide range of viscosities using non-clogging spinning microfilter oil/water separator technology.

NSWC initially demonstrated that the quickest way to alleviate oil spills at sea was to burn the contaminated oil/water mixture in a furnace at sea. However, this was discouraged by the Superfund sponsors. A new concept of separating the oil/water mixture and later disposing of the separated components was explored. A working prototype was developed to prove the concept.

The spinning microfilter separation process was patented by NSWC. NSWC believes that this process may have additional commercial applications.

### Value/Benefits to DoD:

*Supports DoD Management Principle: Promote Basic Research*

The new concept explored under this CRADA has led to the development of a patented process to quickly and effectively separate oil from water with the use of a spinning micro-filter system.

### Benefits to Non-Federal Partner:

Unfortunately, the consortium lost funding and never was able to utilize the process that was developed. However, it is believed that there will be other commercial applications for the process.

# Air Force CRADAs

| | | *Address Warfighting Needs* | *Reduce Cost* | *Strengthen the Industrial Base* | *Promote Basic Research* | *Assure Quality* |
|---|---|---|---|---|---|---|
| AF1 | Automated Software for Composite Material Analysis | | | ● | ● | |
| AF2 | Covert Adjustable Laser Illumination CRADA | ● | | ● | | ● |
| AF3 | Hazardous Materials Management System | | ● | ● | | |
| AF4 | Helmet Mounted Display Fitness of Use | ● | | | ● | |
| AF5 | Ogden Air Logistics Center X-Ray/Computed Topography Sections | | | ● | ● | |
| AF6 | Strategic Avionics Battle Management Evaluation and Research (SABER) | ● | ● | | | |
| AF7 | Test and Evaluation of Imaging System | ● | | ● | | |
| AF8 | USAF CRDA Between Weber State University and the Science and Engineering Laboratory | | | | ● | |
| AF9 | Warhead Arena Test | | | | ● | |
| AF10 | Whole Spacecraft Isolation System for Taurus/GEOSAT | ● | ● | | ● | |

AF1

*Title: Automated Software for Composite Material Analysis*

*Federal Partner: U.S. Air Force Research Laboratory, Materials and Manufacturing Directorate, (AFRL/ML)*

*Federal POC: Dr. Nick Pagano*

*Non-Federal Partner: AdTech Systems Research, Inc.*

*Status: Closed*


*Automated System for Composite Analysis*
*Software and User's Manual*

*Summary:*

Modern composite materials are unique in the directional dependence of their strength, stiffness and thermal expansion characteristics and are not amenable to the use of design and analysis procedures employed for conventional isotropic structural materials. The use of modern composites has been steadily increasing and to make the best use of their capabilities, it is extremely important that sophisticated and reliable analysis procedures be established. A number of computer programs and advanced theories for predicting the response characteristics of advanced composite structural materials have been developed and their use continues to grow.

Under a CRADA, Adtech Systems Research and the Air Force Research Laboratory, Materials and Manufacturing Directorate, were able to develop a fully documented commercial software package, Automated Software for Composite Analysis (ASCA). This software package consists of solution procedures for the efficient analysis of composite materials that are leading to new and innovative avenues for developing optimum designs and establishing new goals.

## Value/Benefits to DoD:

*Supports DoD Management Principle: Strengthen the Industrial Base*

The software package developed under this CRADA is serving the needs of both the Government and private industry. Customers of the package include the aircraft industry (such as Boeing, Lockheed, and United Technologies), composite materials manufacturers, the automobile industry, academia, research organizations, and spacecraft manufacturers. The number of organizations actively pursuing the development of the use of composite materials is growing.

*Supports DoD Management Principle: Promote Basic Research*

This CRADA provided DoD with the availability of automated software that provides a better understanding of composites and can be used to perform complex composites analysis in the design of military systems. ASCA has been used by many major manufacturers of military systems employing advanced composites.

### Benefits to Non-Federal Partner:

This CRADA led to the commercialization of a software package. Based on the experience with this software code, AdTech has developed additional software packages.

### Other Benefits:

The Air Force received $2K in royalties from the software sales to industry. The value to the Directorate of developing the program and software to reliably perform composite analysis is conservatively estimated to be $100K, in terms of equivalent contracting costs.

## AF2

*Title: Covert Adjustable Laser Illuminator CRADA*

*Federal Partner: U.S. Air Force Research Laboratory, Directed Energy Directorate, (AFRL/DE)*

*Federal POC: Capt. William Cooley*

*Non-Federal Partner: FLIR Systems, Inc. (FSI)*

*Non-Federal POC: John Miller*

*Status: Open*

*Summary:*

The objective of this CRADA between the Air Force Research Laboratory, AFRL, and FLIR Systems, Inc., FSI, was to explore the feasibility, applicability, safety and utility of a fiber coupled diode laser to illuminate an image from a gimbaled assembly. An eye-safety analysis, a positive phenomenology study, and successful ground and airborne field tests were performed.

The integrated system developed in this CRADA enhances FLIR's gimbaled IR sensor system by allowing an area of terrain to be illuminated by a laser and viewed on a screen. The range for this system is approximately 1 km. When used in search and rescue operations, the viewing range can be 5 to 10 km.

FLIR transferred $10K to the AFRL on the front-end to cover travel costs associated with AFRL personnel going to Oregon for collaborative meetings. It is estimated that royalties from future licenses will bring $.5M into the AFRL.

### Value/Benefits to DoD:

*Supports DoD Management Principle: Address Warfighting Needs*

Many Federal and local government entities have a need to positively identify ships and aircraft that are detected by electro-optical sensor systems. This identification must be quick, accurate, and admissible in a court of law. This CRADA has proved that this can be accomplished even for difficult cases such as maritime patrol.

*Supports DoD Management Principle: Strengthen the Industrial Base*

This work resulted in transitioning the technology to a FSI where they are actively pursuing incorporating the technology into a commercial system. Potential buyers include the U.S. Border Patrol, U.S. Coast Guard, Canadian Government, and the German Navy.

*Supports DoD Management Principle: Assure Quality*

The development of an integrated system was derived from the core competencies of both the Air Force Research Laboratory and FLIR Systems Inc. While the Air Force's expertise is in the development of fiber coupled diode lasers, FSI's expertise is as a commercial vendor for products that employ a stabilized Gimbal sensor system with thermal capabilities.

### Benefits to Non-Federal Partner:

The industrial partner is actively pursuing commercializing the technology developed under this CRADA.

## AF3

*Title: Hazardous Materials Management System*

*Federal Partner: U.S. Air Force Research Laboratory, Materials and Manufacturing Directorate (AFRL/ML)*

*Federal POC: Frank Borasz, Larry Bidwell and Haywood Burnette*

*Non-Federal Partner: Modern Technologies Corporation*

*Non-Federal POC: Larry Harms*

*Status: Closed*


*Summary:*

The U.S. Air Force Research Laboratory, Materials and Manufacturing Directorate (AFRL/ML), uses more than 10,000 different chemicals in over 40,000 containers in its 15 facilities. This level of activity and complexity necessitates a very aggressive pollution prevention program to assure that health and safety are a top priority and that environmental issues are correctly managed.

The AFRL/ML in cooperation with Modern Technologies Corporation developed a computerized system using bar code technology to coordinate the tracking and control of hazardous materials including levels, location changes, usage rates, and other critical data. The system, LINDEN™ Environmental Management System (LINDEN™), enables effective centralized hazardous materials management, waste minimization and pollution prevention efforts, a reduction in materials costs, and prevention of materials shortages through more effective control and retrieval. Using system data, the storage of hazardous chemicals is consolidated, helping to eliminate duplicate and excess stock.

At the Directorate, over 40,000 hazardous materials and waste containers were tracked throughout their complete use life, resulting in purging of over 10,000 hazardous material containers no longer needed by researchers. More than 400 containers of unknown materials were identified, classified and eliminated. In some cases, the effort permitted the identification of replacement chemicals that are less harmful to the environment. The system was extended to include laboratory facilities across Wright-Patterson AFB and has been selected for implementation at other government installations.

### Value/Benefits to DoD:

*Supports DoD Management Principle: Reduce Cost*

The value in using the LINDEN™ system to reliably manage a hazardous materials program at the Air Force Research Laboratory, Materials and Manufacturing Directorate, is conservatively estimated to be $10K in terms of equivalent contracting costs. The LINDEN™ system saves labor hours that would typically be spent on documentation and tracking.

*Supports DoD Management Principle: Strengthen the Industrial Base*

The LINDEN™ Environmental Management System is a commercialized product that is now available for both Government and industry use.

### Benefits to Non-Federal Partner:

Modern Technologies was able to use the Air Force facilities and personnel as a means of Beta testing their software package. As a result of the feedback received from the Beta test site, the industrial partner was able to develop and commercialize the LINDEN™ software package.

Recently, Modern Technologies has produced a more advanced system with additional functionality and a web interface.

## Other Benefits:

The Air Force received $4K in royalties from the sale of the LINDEN™ system to industry. At least $100K in software has been installed at government installations such as the Center for Disease Prevention and Control, Atlanta, GA and the Army Redstone Arsenal in Huntsville, AL.

## AF4

*Title: Helmet Mounted Display Fitness of Use*

*Federal Partner: Air Force Research Laboratory, Human Effectiveness Directorate, (AFRL/HE)*

*Federal POC: Brian Tsow*

*Non-Federal Partner: KOPIN Corporation*

*Non-Federal POC: Mike Presz*

*Status: Open*

*Summary:*

Wearable computers and eye piece technology are stepping stones to providing maintenance technicians with the right information at the right time and place, enabling agile combat support. In a CRADA between the Air Force Research Laboratory, Human Effectiveness Directorate, and KOPIN Corporation, a fitness of use study was undertaken to examine the effectiveness of Helmet Mounted Displays (HMD) in mobile computing applications.

The two main elements in the fitness of use study included a visual effects study and a usability study. This CRADA provided KOPIN with access to an actual military maintenance environment for the evaluation of the HMDs for use as a maintenance tool. The Air Force was able to provide valuable feedback to KOPIN on the use of the HMD resulting in a commercialized product.

For the study, three HMDs and one man-mounted battery pack kit (including belt mounted battery pack, two batteries, charger and interface cables) were fabricated, tested and delivered to the Air Force. These hardware assets are to remain the property of the Air Force in exchange for services rendered and will be maintained by KOPIN for a period of one year following completion of the study at no charge to the Air Force.

### Value/Benefits to DoD:

*Supports DoD Management Principle: Address Warfighting Needs*

The information collected under this CRADA will be used to support Air Force Integrated Maintenance Information System (IMIS) efforts that are currently using portable computers for the display of maintenance technical information. Several of the IMIS programs in the Air Force (F-22 IMIS, F-16 IMIS, and JSTARS IMIS) are interested in monocular displays for possible out-year technology insertion.

The CRADA effort identified deficiencies and areas for improvement in miniature display devices and their mounting type. The CRADA effort has provided a much clearer picture of the technician's needs in a real flight line situation and it has shown the Air Force that there may be a better way to maintain their aircraft.

*Supports DoD Management Principle: Promote Basic Research*

AFRL/HE possesses one of the largest data bases in the DoD on actual maintenance technician performance with the use of a monocular display device. As part of the CRADA, the Air Force Research Laboratory collected additional quantitative and qualitative data on the use of a monocular eye piece device for presenting maintenance technical instructions to C-141 and F-16 technicians performing a routine maintenance repair.

### Benefits to Non-Federal Partner:

This CRADA provided KOPIN with access to a real working maintenance area which provided them with the information necessary to modify their display. KOPIN also believes that the automotive industry and other industries may benefit from this product leading to new market opportunities.

## Other Benefits:

The estimated value of the hardware assets is $17,250 (not including time and material expenses associated with maintenance and repair for the Air Force). The one year maintenance and service value is estimated at $3,000. In addition, KOPIN will fund the Air Force Research Laboratory an additional $10,000 for a total CRADA resource value (funds, personnel, services, property and equipment) of $30,000.

## AF5

*Title: Ogden Air Logistics Center X-ray/Computed Tomography Sections*

*Federal Partner: Odgen Air Logistics Center*

*Federal POC: Art McCarty*

*Non-Federal Partner: ARACOR, Sunnyvale, CA*

*Non-Federal POC: Richard Savage*

*Status: Open*

*Summary:*

The objective of the CRADA between ARACOR and the Ogden Air Logistics Center is to provide ARACOR access to unique Air Force Computed Tomography (CT) equipment for evaluating new hardware and software features and exploring new applications for the powerful, new CT technology.

The Air Force currently uses an ARACOR CT machine to examine its Minuteman solid rocket motors for cracks and abnormalities within the propellant. ARACOR wanted to enhance the machine's capabilities with new software and hardware features, but was limited in available demonstration sites. This CRADA provided ARACOR with the ability to utilize the Air Force equipment for testing and evaluation of its new hardware and software configurations.

The Air Force made the CT equipment and facilities available to ARACOR on a non-interference basis and was reimbursed $75K for associated direct support costs. The CRADA allowed unique Air Force equipment to be used, in otherwise idle times, to inspect rocket motors.

The technology used in this CRADA enables parts to be examined for interior cracks and deformities by a machine much like x-ray equipment. Methods of inspecting canisters designed for storage and disposal of nuclear waste were evaluated under this CRADA. ARACOR is also evaluating CT as a key tool for reverse engineering parts for which there are no accurate engineering drawings or CAD files. DOE has expressed interest in this technology for the examination of nuclear weapons and parts. Chrysler, Ford and VW have also expressed interest for the inspection of various parts.

This CRADA was extended for an additional two years.

### Value/Benefits to DoD:

*Supports DoD Management Principle: Strengthen the Industrial Base*

The DLA has shown interest in the use of CT as a tool for the reverse engineering of parts for applications in the resupply of defense components, such as spare parts for aircraft, in cases where there are no remaining commercial sources.

DoE is interested in using this CT technology for examining nuclear weapons to support disassembly. The auto industry is also interested in this type of inspection technology for use in the examination of various auto parts.

*Supports DoD Management Principle: Promote Basic Research*

Basic research was advanced in the use of CT technology through the sharing of research data collected by the industrial partner. The Air Force also benefited from exposure to new test procedures, software, and analysis techniques.

### Benefits to Non-Federal Partner:

The industrial partner has potential markets for this nondestructive inspection technology in the auto industry as well as with DoE and DLA.

## AF6

*Title: Strategic Avionics Battle Management Evaluation and Research, (SABER)*

*Federal Partner: U.S. Air Force Research Laboratory, Human Effectiveness Directorate, (AFRL/HE)*

*Federal POC: Gil Cooperman*

*Non-Federal Partner: Northrop Corporation*

*Non-Federal POC: James Reis*

*Status: Closed*

*Summary:*

The objective of this CRADA was to plan, design, conduct, analyze, document, and report on concept demonstrations of advanced Air Force direct attack conventional target acquisition and weapon delivery avionics systems. As a result of this effort, the Air Force gained operator/system performance data from an expanded set of critical laboratory experiments which benefited the Air Force Precision Strike Demonstrations and other target acquisition and weapon delivery programs.

### Value/Benefits to DoD:

*Supports DoD Management Principle: Address Warfighting Needs*

The Air Force received and integrated into their simulator facilities, improved/enhanced aircraft flight and conventional weapon delivery and weapon flyout models not available through in-house R&D project funds. The data produced was made available to the Air Force Precision Strike Demonstration Program (ARTEMIS), to HQ Air Combat Command Deputy for Requirements, to AFRL Science and Technology, and to several bomber aircraft System Program Offices. The data gave the laboratory insight into expected systems performance, operational utility and the identification of crew station integration and training system impacts. This CRADA allowed the actual warfighters, who would someday use the equipment, to provide feedback to Northrop on their system.

*Supports DoD Management Principle: Reduce cost*

The feedback from the warfighters on the Northrop system provided Northrop with information that was used to modify and improve their design early in the development cycle, saving Northrop and the Government time and money.

### Benefits to Non-Federal Partner:

Early feedback from the warfighters on the target acquisition and weapon delivery avionics systems was used to modify and improve the design early in the development cycle.

### Other Benefits:

This CRADA, which is ongoing, has allowed a concept to be evaluated very early in the program in a non-competitive environment which benefited both partners. The Air Force received $300K in reimbursement costs from Northrop.

## AF7

*Title: Test and Evaluation of Imaging System*

*Federal Partner: U.S. Air Force Development Test Center, Eglin AFB*

*Federal POC: Russell Bauldree*

*Non-Federal Partner: Eastman Kodak Company*

*Status: Closed*

*Summary:*

The purpose of this CRADA was to evaluate the performance of the Kodak Megapixel Imaging Technology (MITE) Imaging System against ground threat targets under a variety of tactical flight conditions. This work was used as a proof of concept leading to a fully ruggedized, fieldable tactical imaging system and provided insights into the applicability of this technology to military flight operations. The MITE system was integrated into a Supersonic Airborne Tri-Gimbal Infrared System pod by Air Force personnel and tested at Eglin AFB over a land test range using a high performance aircraft.

### Value/Benefits to DoD:

*Supports DoD Management Principle: Address Warfighting Needs*

The imaging system was integrated into an F15 so that it could be evaluated by an actual pilot who would be using the system. The Air Force received hands-on experience with state-of-the-art technology that may provide an increased operational capability.

*Supports DoD Management Principle: Strengthen the Industrial Base*

As a result of this evaluation, Kodak was able to refine the design leading to the commercialization of a new product.

### Benefits to Non-Federal Partner:

Kodak received an assessment of their product, which allowed them to fine-tune the imaging system which led to design modifications of the MITE system before final production efforts were initiated. Kodak was able to commercialize a new product, therefore, enhancing their market position in this area.

### Other Benefits:

In Kodak advertising the evaluation performed at the Eglin test facility, interest by other industrial customers who could also benefit from the test and evaluation expertise was generated, thereby, providing additional business for the Eglin facility.

AF8

*Title: USAF Cooperative Research and Development Agreement Between Weber State University and the Science and Engineering Laboratory*

*Federal Partner: Ogden Air Logistics Center, Technology and Industry Support Directorate, (OO-ALC/TI)*

*Federal POC: Steve Nelson*

*Non-Federal Partner: Weber State University (WSU)*

*Non-Federal POC: Todd Nilsen*

*Status: Open*

*Summary:*

Weber State University (WSU) is a Center for Excellence for Chemical and Materials Analysis which attracts research projects from local private sector businesses. Analytical costs associated with these research projects are paid by these businesses to WSU. To support these research projects, a CRADA between the Ogden Air Logistics Center, Technology and Industry Support Directorate (OO-ALC/TI) and WSU was developed to provide WSU faculty and staff access to the Air Force Laboratory test instrumentation and/or its science and engineering personnel. WSU pays the Air Force its normal shop rate for costs incurred in item testing, equipment usage, training, and consultive work for these research projects.

## Value/Benefits to DoD:

*Supports DoD Management Principle: Promote Basic Research*

This CRADA established a cooperative association between university academia and Air Force scientists. DoD expertise as well as facilities were shared with the university and the community thus fostering and promoting research between the two partners. Through this agreement, the OO-ALC/TI laboratory personnel was exposed to collegiate industrial technology, current research that is adaptive, fellowship with professional individuals, and associations with graduate students that may someday be future DoD scientists, engineers and technicians.

Although the intent of this CRADA is to promote basic research, individual projects pursued under this agreement may support other DoD S&T management principles.

## Benefits to Non-Federal Partner:

This CRADA has allowed the WSU lab personnel and collegiate staff to resource unique laboratory testing, access particular scientific equipment, and become involved in consultative evaluations with experienced DoD scientific and engineering personnel. The exchange of test data, consultative sessions and professional personnel interaction has exposed WSU's chemical/materials staff and student population to realistic industrial laboratory education.

## AF9

*Title: Warhead Arena Test*

*Federal Partner: U.S. Air Force Development Test Center, Eglin AFB*

*Federal POC: Dennis Schneider*

*Non-Federal Partner: Hughes Missile Systems*

*Non-Federal POC: Thomas Bootes*

*Status: Closed*

*Summary:*

The purpose of this CRADA was to determine the blast and fragmentation characteristics of a Hughes technology demonstration warhead. The data collected during this effort was to be used in effectiveness analyses to support both warhead design efforts as well as advanced explosives development.

The test was conducted at the arena test facility at Eglin AFB. Eglin was reimbursed $58K for the use of their facilities for this testing. This CRADA enabled Hughes to use an arena test site which exists at Eglin AFB to test a warhead.

### Value/Benefits to DoD:

*Supports DoD Management Principle: Promote Basic Research*

Warhead fragmentation and blast characteristics test data was obtained in support of Hughes proprietary technology demonstration warhead design. This test data provided Eglin, AFB with insight into the fragmentation pattern of a new warhead design as well as the performance of the explosive fill.

### Benefits to Non-Federal Partner:

Through the work performed under this CRADA, Hughes was able to demonstrate to the Air Force that their warhead had some very unique features. The knowledge gained in fragmentation patterns of the new warhead design as well as performance of the explosive fill led to future contracts in this area.

## AF10

*Title: Whole Spacecraft Isolation System for Taurus/GEOSAT*

*Federal Partner: U.S. Air Force Research Laboratory, Space Vehicles Directorate, (AFRL/VS)*

*Federal POC: Dr. Dino Scuilli*

*Non-Federal Partner: Orbital Sciences Corporation (ORBITAL)*

*Non-Federal POC: Sharon Roberts*

*Status: Open*

*Summary*

The Air Force Research Laboratory (AFRL), Space Vehicles Directorate has been actively pursuing ways to reduce loads imparted to satellites. A concept developed at AFRL is a "whole-spacecraft isolation system" in which the vibrations imparted to the satellite are reduced. This system replaced the 60 bolts that attach the separation system to the avionics cone and exceeded or met all performance requirements levied by ORBITAL.

Under this CRADA between ORBITAL and AFRL, AFRL was to design, build and flight qualify a whole-spacecraft isolation system and ORBITAL was to fly the AFRL's isolation system on their Taurus/GEOSAT Follow-On (GFO) mission (GFO is a Navy satellite being built by Ball Aerospace). In return, ORBITAL would recover the GFO safety margins using the whole-spacecraft isolation system. This flight opportunity with ORBITAL occurred because the Navy satellite GFO had unsatisfactory stress margins on ORBITAL's Taurus launch vehicle, and the AFRL's whole spacecraft isolation system could significantly recover their stress margins.

### Value/Benefits to DoD:

*Supports DoD Management Principle: Address Warfighting Needs*

Any reduction in launch loads corresponds directly to savings in satellite weight which can then be used for additional instruments to increase the science or performance of the satellite. Also, the extra weight can be used to add more propellant to the satellite; thereby, increasing the lifetime of the satellite.

*Supports DoD Management Principle: Reduce Cost*

The whole-spacecraft isolation system helps reduce life-cycle costs of future Air Force satellite systems by significantly reducing the launch vehicle environments. It is projected that this system has saved the Navy GFO program a few million dollars and 3-6 months in redesign efforts. Similar results are expected for all other satellites launches.

*Supports DoD Management Principle: Promote Basic Research*

The Air Force attained and analyzed actual flight data from ORBITAL on the performance of the isolation system relative to its performance from simulation and ground testing.

### Benefits to Non-Federal Partner:

In reducing launch loads imparted to the GFO satellite, additional capabilities can be used on future satellites. The satellite businesses welcomes the opportunity to increase satellite capabilities.

# Interview Guides

## CRADA Federal POC Questions

1. Confirm whether the CRADA is Open or Closed.
2. What was the period of performance?
3. How was the CRADA initiated?
4. Type of CRADA (tech assistance, material transfer, facility share, knowledge share, etc.)
5. Were objectives laid out in the CRADA?
   Were these objectives met?
6. How would objectives been met without CRADA mechanism?
7. What are the associated costs of coordinating a CRADA vs. other mechanisms?
8. What was the outcome of the CRADA?
   - Was there a successful process of product commercialization?
   - Was a paper written?
   - What was the savings– short/long term?
   - Other benefits? (access to state-of-the-art technologies/facilities, cost avoidance)
   - etc.
9. What was the associated input cost?
10. Did industry input any $$?
11. What is the estimate of how many S&E man-hours were expended?
12. Do you know if jobs were created as as result of this CRADA?
13. Was a marketing assessment conducted? (identified other applications for technology?)
14. Were there other applications for the technology?
15. Did you have a positive experience overall?
16. What made this CRADA a success?

## CRADA Non-Federal POC Questions

1. Confirm whether the CRADA is Open or Closed.
2. What was the period of performance?
3. How was the CRADA initiated?
4. Type of CRADA (tech assistance, material transfer, facility share, knowledge share, etc.)
5. Were objectives laid out in the CRADA?

   Were these objectives met?
6. How would objectives been met without CRADA mechanism?
7. What are the associated costs of coordinating a CRADA vs. other mechanisms?
8. What was the outcome of the CRADA?
   - Was there a process of product commercialization?
   - Was there savings to the government as a result of this product/process?
   - Was a paper written?
   - What was the savings – short/long term?
   - Other benefits? (access to state-of-the-art technologies/facilities, cost avoidance)
   - etc.
9. What was the associated input cost?
10. Did industry input any $$?
11. Did the work continue after the CRADA ended?
12. Was a marketing assessment conducted? (identified other applications for technology? Did a Government employee participate in market assessment?)
13. Were there other applications for the technology identified (used or not used)?
14. Were any jobs created as a result of this CRADA?
15. What was your experience overall?
16. What made this CRADA a success?
17. As a result of this CRADA, what do you think the benefits back to the government were?
18. Where could improvements in the CRADA process be made?

# POC Lists

## ARMY Points of Contact

| CRADA Name | Federal Agency | Federal POC | Telephone# | Non-Federal Partner | Non-Federal POC | Telephone# |
|---|---|---|---|---|---|---|
| Advanced Technology for High Resolution Physics Based Interative Simulation | US Army Communications and Electronics Command, Night Vision and Electronic Sensors Directorate | Max Lorenzo | 703-704-3185 | Silicon Graphics, Inc. | Bob Paddison, Judith Pafford | 301-572-1685 972-788-4122 |
| Blanket CRADA between Ford, General Motors, Chrysler, and the US Army Tank Automotive Research, Development and Engineering Center | US Army Tank Automotive Research, Development and Engineering Center | Doug Miller | 810-574-5793 | Ford Motor Company, Chrysler, and General Motors | | |
| Construction Equipment Performance Optimization | Cold Regions Research and Engineering Laboratory | Sally Shoop | 603-646-4321 | Caterpillar, Inc. Goodyear Tire and Rubber Company | Paul Corcoran, Mike Trinko | 309-698-5866 330-796-1722 |
| CORE-LOC Concrete Armor Unit | US Army Engineers' Waterways Experiment Station | Jeff Melby | 601-634-2062 | A. R. Wijnberg | | |
| Development of Biodegradable Polymers | US Army Natick Research, Development and Engineering Center | Dr. Jo Ann Ratto | 508-233-5315 | Zeneca (Imperial Chemical Industries (ICI) Americas) | | |
| Development of Novel Imaging System for Medical, Non-Desctructive Testing & Investigation of Micro-Electronic Circuits | US Army Communications and Electronics Command, Night Vision and Electronic Sensors Directorate | Conrad Terrell | 703-704-2809 | Martin E. Lasser, Inc. | Marvin Lasser | 301-208-6775 |
| Evaluation of Electron Cyclotron Resonance Plasma Technology | US Army Communications and Electronics Command, Night Vision and Electronic Sensors Directorate | Jack Dinan | 703-704-3234 | Texas Instruments | Robert Keller | 972-995-0181 |
| Formulation of a Liposomal Transdermal Vaccine System and other Novel Pharmaceuticals | Walter Reed Army Institute of Research | Dr. Carl Alving | 202-782-3248 | Medical Technology and Practice Patterns Institute, Inc Iomai | Dennis Cotter Dean Lewis | 202-333-8841 202-955-7120 |
| Full Scale Fabrication & Optimization of Composite Cylinder Processing | US Army Research Laboratory | Dana Granville | 410-306-0777 | Composite Development Corporation | | |
| Vaccines for Infectious Diseases | Walter Reed Army Institute of Research | Dr. Ken Eckels | 301-295-7757 | Ora Vax, Inc. | Tom Monas | 617-494-1339 |

## NAVY Points of Contact

| CRADA Name | Federal Agency | Federal POC | Telephone# | Non-FEDERAL Partner | Non-Federal POC | Telephone# |
|---|---|---|---|---|---|---|
| CRADA Between The Naval Training Systems Center and Computer Group of Motorola, Inc. | Naval Air Warfare Center, Training System Division | David Kotick | 407-380-4606 | Motorola, Inc. | Ralph Whitney | 407-823-7014 |
| Deep-Towed Acoustic/Geophysical System | Naval Research Laboratory | Joseph Gettrust | 601-688-5090 | Seafloor Sciences International | Donald Hussong | 206-441-9305 |
| Demonstration of CL-20 Based Explosive Formulations | Naval Air Warfare Center Weapons Division, China Lake | Tom Boggs | 760-939-1083 | Thiokol Corporation | Charles Zisette | 801-863-4219 |
| Detection of Contraband and Narcotics by Nuclear Quadrupole Resonance (NQR)/Fast Recovery Time Nuclear Quadrupole Resonance Detection | Naval Research Laboratory | Dr. Al Garroway | 202-767-2323 | Quantum Magnetics | Dr. Lowell Burnett | 619-566-9200 |
| Electric Vehicle/Hybrid Electric Vehicle Battery Chemistry Research and Evaluation | Naval Surface Warfare Center, Crane Division | Jim Gucinski | 812-854-6150 | AdvanceTek | Ellen Engleman | 317-615-0022 |
| Exploring the Effects of Lipid-Lowering Agents on Complex Cognitive and Performance Tests | Naval Medical Research Institute | LCDR Eric Bower, | 850-452-8091 | Bristol - Myers Squibb | Dr. Joan Stagger | 609-897-2838 |
| New Paint Formulations for Fluorinated Polyurethane Resins | Naval Research Laboratory | Dr. Robert Brady | 202-767-2268 | 21st Century Coatings, Inc. | Grover Howard<br>Gene Lindsey | 703-379-1080<br>703-548-8622 |
| Ocean Bottom Profiler (OBP) Joint Project | Naval Undersea Warfare Center, Newport Division | Ken Walsh | 401-832-2282 | Precision Signal, Inc. | Dr. Lester LeBlanc | |
| Technical Assistance to CIT | Naval Surface Warfare Center, Dahlgren Division | Ramsey Johnson | 540-653-2680 | Virginia Center for Innovative Technology | Dr. Eilene Heveron<br>Dr. Ed Veazey | 703-689-3000<br>540-775-2651 |
| Use of Spinning Microfilters to Separate Oil from Water for Abatement of Marine Spills | Naval Surface Warfare Center, Carderock Division | Dr. E. Fischer | 301-227-4400 | Marine Spill Response Corporation | | |

## AIR FORCE Points of Contact

| CRADA Name | Federal Agency | Federal POC | Telephone# | Non-FEDERAL Partner | Non-Federal POC | Telephone# |
|---|---|---|---|---|---|---|
| Automated Software for Composite Material Analysis | Air Force Research Laboratory, Materials and Manufacturing Directorate | Dr. Nick Pagano | 937-426-2045 | AdTech Systems Research, Inc. | | |
| Covert Adjustable Laser Illumination CRDA | Air Force Research Laboratory, Directed Energy Directorate | Capt. William Coc | 505-846-5899 | FLIR Systems, Inc. | John Miller | 503-684-3731 |
| Hazardous Materials Management System | Air Force Research Laboratory, Materials and Manufacturing Directorate | Frank Borasz<br>Larry Bidwell<br>Haywood Burnette | 937-656-9208<br>937-255-2917<br>937-255-4689 | Modern Technologies Corporation | Larry Harms | 937-226-7724 |
| Helmet Mounted Display Fitness of Use | Air Force Research Laboratory, Human Effectiveness Directorate | Brian Tsow | 937-255-8896 | KOPIN Corporation | Mike Presz | 408-364-0271 |
| Ogden Air Logistics Center X-Ray/Computed Tomography Sections | Ogden Air Logistics Center, Technology and Industry Support Directorate | Art McCarty | 801-777-6080 | ARACOR | Richard Savage | 408-733-7780 |
| Strategic Avionics Battle Management Evaluation and Research (SABER) | Air Force Research Laboratory, Human Effectiveness Directorate | Gil Cooperman | 937-255-3727 | Northrop Corporation | James Reis | 562-942-6130 |
| Test and Evaluation of Imaging System | Air Force Development Test Center, Eglin AFB | Russell Bauldree | 850-882-2594 | Eastman Kodak Company | | |
| USAF CRADA Between Weber State University and the Science and Engineering Laboratory | Ogden Air Logistics Center, Technology and Industry Support Directorate | Steve Nelson | 801-775-2482 | Weber State University | Todd Nilsen | 801-626-6144 |
| Warhead Arena Test | Air Force Development Test Center, Eglin AFB | Dennis Schneider | 850-882-9175 | Hughes Missile Systems Company (now Raytheon) | Thomas Bootes | 520-794-1683 |
| Whole Spacecraft Isolation System for Taurus/GEOSAT | Air Force Research Laboratory, Space Vehicles Directorate | Dr. Dino Scuilli | 505-846-8256 | Orbital Sciences Corporation | Sharon Roberts | 703-406-5248 |

## Other Points of Contact

| Federal Agency | Service | POC | Telephone # |
|---|---|---|---|
| Army Research Laboratory | Army | James Wanko | 301-394-2529 |
| Army Research Laboratory | Army | Michael Rausa | 410-278-5028 |
| Walter Reed Army Institute of Research | Army | Dr. Paul Mele | 202-782-8163 |
| US Army Engineers' Waterways Experiment Station | Army | Phil Stewart | 601-634-4113 |
| US Army Communications and Electronics Command | Army | Louis Jakub | 732-427-2690 |
| Cold Regions Research and Engineering Laboratory | Army | Peter Smallridge | 603-646-4445 |
| US Army Natick Research, Development and Engineering Center | Army | Bob Rosenkrans | 508-233-5296 |
| Office of Naval Research | Navy | Nancy Groves | 703-696-5991 |
| Naval Medical Research Command | Navy | David Spevak | 301-295-6760 |
| Air Force Research Laboratory | Air Force | Steve Guilfoos | 937-656-9021 |
| Air Force Research Laboratory, Materials and Manufacturing Directorate | Air Force | Patrick Rodriguez | 505-846-0857 |
| Air Force Research Laboratory, Human Effectiveness Directorate | Air Force | Scott Hall | 937-255-2423 |
| Air Force Development Test Center, Eglin AFB | Air Force | Buddy Kinlaw | 850-882-8096 |
| Ogden Air Logistics Center, Technology and Industry Support Directorate | Air Force | Richard Healy | 801-777-2307 |
| Air Force Research Laboratory, Space Vehicles Directorate | Air Force | Vince Miller | 937-255-5066 |

# Endnotes

[1]National Technology Transfer Center, Technology Transfer Resource Guide, http://www.nttc.edu/training/guide/seca01.html, April 4, 1998.

[2]David J Roessner, "What Companies Really Want From the Federal Labs," ChemTech, November 1993, p. 12.

[3]FY93 Defense Authorization Act, Public Law: 102-484, October 23, 1992

[4]William J Perry, "DoD Domestic Technology Transfer/Dual Use Technology Development Domestic Technology...," June 2, 1995.

[5]"DoD Technology Transfer Best Practices and Lessons Learned," Draft Final Report, Booz-Allen & Hamilton, July 1997, p. 3-14.

[6]"Effective Partnering: A Report to Congress on Federal Technology Partnerships," U.S. Department of Commerce, Office of Technology Policy, April 1996, p. 11.

[7]"Technology Transfers: Benefits of Cooperative R&D Agreements," GAO Report, RCED-95-52, December 1994.

[8]David J Roessner, "What Companies Really Want from the Federal Labs, Chemtech, 23, 11, November 1993.

[9]Department of Defense Technology Transfer Program, Draft Instruction, Number 5535.XX, DDR&E, p. 2.

[10]Defense Science Board Task Force on Lab Management (DSB-LM) Interim Report, (www.dtic.mil/labman/projects/docs.html)

[11]Andrew Dougherty, and Michael Irish, "Shared Investment-Shared Return, Industry/Government Technology programs, An Executive Summary of Research," Economic Strategy Institute, Washington, DC, June 1995, p. 1.

[12]Stevenson-Wydler Technology Innovation Act of 1980, Public Law: 96-480, October 21, 1980

[13]Federal Technology Transfer Act of 1986, Public Law: 99-502, October 20, 1986

[14]Executive Order 12591: Facilitating Access to Science and Technology, December 22, 1987

[15]National Technology and Advancement Act of 1995, Public Law: 104-113, March 7, 1996

[16]Technology Transfer Commercialization Act of 1998, H.R. 2544, Passed House as of July 14, 1998

[17]AFMC Technology Transfer Handbook, November 1995, p. H-8.

[18]AFMC Technology Transfer Handbook, November 1995, p. H-10.

[19]AFMC Technology Transfer Handbook, November 1995, p. H-11.

[20]Department of Defense Technology Transfer Program, Draft Instruction, Number 5535.XX, DDR&E, p. 9.

[21]"DoD Technology Transfer Best Practices and Lessons Learned," Draft Final Report, Booz-Allen & Hamilton, July 1997, p. 3-15.

[22]David J Roessner, "What Companies Really Want From the Federal Labs," Chemtech, 23, 11, November 1993, p. 13.

[23]David J Roessner, "What Companies Really Want From the Federal Labs," Chemtech, 23, 11, November 1993, p. 15.

[24]"DoD Technology Transfer Best Practices and Lessons Learned," Draft Final Report, Booz•Allen & Hamilton, July 1997, p. 3-12.

[25]Department of Defense Technology Transfer Program, Instruction, Number 5535.XX, DDR&E, p. 13.

[26]Department of Defense Director, Defense Research and Engineering, Defense Science and Technology Strategy, May 1996

[27]"Effective Partnering: A Report to Congress on Federal Technology Partnerships," U.S. Department of Commerce, Office of Technology Policy, April 1996, p. 10.

[28]"Technology Transfers: Benefits of Cooperative R&D Agreements," GAO-RCED-95-52, December 1994, p. 3.

[29]Gregory M. Glenn, Mangala Rao, Gary R. Matyas, and Carl R. Alving, "Skin Immunization Made Possible by Cholera Toxin," Nature, Vol. 391, No. 6670, 851, February, 26, 1998

[30]U.S. Commercial and Military Infrared System Markets: Emerging Materials, Price Reductions Offer Excellent Opportunities, Frost & Sullivan, 1995, p. 2-3.

[31]U.S. Commercial and Military Infrared System Markets: Emerging Materials, Price Reductions Offer Excellent Opportunities, Frost & Sullivan, 1995, p. 1-1.

# Bibliography

AFMC Technology Transfer Handbook. Air Force Material Command, November 1995.

Anderson, Lawrence K. and Brian D. Gurney. Benchmarking Best Practices in Technology Transfer. Financial Report. Colorado Institute for Technology Transfer and Implementation, March 1994.

Archibald, Robert B., David H. Finifter, Nanette R. Smith. Working Paper, Measuring the Economic Benefits of Technology Transfer from a National Laboratory: A Primer. The Thomas Jefferson Program in Public Policy, The College of William and Mary, Williamsburg, VA.

"Assessing Benefit to the Navy." Final Draft, Domestic Technology Transfer Program, SAIC, 3/18/96.

Bozeman, Barry and Michael Crow. Federal Laboratories in the National Innovation System: Policy Implications of the National Comparative Research and Development Project, May 1995.

Carr, Robert K. Measurement and Evaluation of Federal Technology Transfer. Proceedings of the 20th Annual Meeting of the Technology Transfer Society, Washington, DC, July 1995.

The Commercialization of Federally Funded Research. ARCH Venture Partners, November 1993, 295-105, pp2-7.

Diffusing Innovations, Implementing the Technology Transfer Act of 1986, GAO Report, PEMD-91-23. Report to the Chairman, Committee on Science, Space, and Technology, House of Representatives, May 1991.

Department of Defense Directive. Department of Defense Technology Transfer Program, DDR&E, Number 5535.3.

Department of Defense Draft Instruction. Department of Defense Technology Transfer (T2) Program, DDR&E, Number 5535.XX.

"DoD Technology Transfer Best Practices and Lessons Learned." Draft Final Report, Booz•Allen and Hamilton, Arlington, VA, July 1997.

Dougherty, Andrew and Michael Irish. Shared Investment-Shared Return, Industry/Government Technology Programs, An executive Summary of Research. Economic Strategy Institute, Washington, DC, June 1995.

"Effective Partnering: A Report to Congress on Federal Technology Partnerships." U.S. Department of Commerce, Office of Technology Policy, April 1996

"Facilitating Access to Science and Technology." Executive Order 12591. December 22, 1987. http://thomas.loc.gov (October 15,1997).

Federal Technology Transfer Act of 1986. Public Law: 99-502. October 20, 1986. http://thomas.loc.gov (October 15,1998)

"From Lab to Market." A Proposal for a Framework for Measuring and Evaluating Technology Transfer from the Federal Laboratories to Industry, published in Kassicieh and Radosevich, Plenum Press, New York, 1994.

FY93 Defense Authorization Act, Public Law: 102-484, October 23, 1992

Geisler, Eliezer and Christine Clements. Commercialization of Technology from Federal Laboratories: The Effects of Barriers, Incentives and the role of Internal Entrepreneurship. Report to the National Science Foundation, Research on Science and Technology Program, Grant No. 94-01432, August 1995.

Gibson, David V., James E. Jarrett, and George Kozmetsky. "Customer Assessment of Martin Marietta Energy Systems, Inc. (MMES) CRADA Program," IC2 Institute. The University of Texas at Austin, April 1995.

Guston, David H. Technology Transfer and the Use of CRADAs at the National Institute of Health.

National Science Board, Science and Engineering Indicators-1998. Arlington, VA: National Science Foundation, 1998

National Technology and Advancement Act of 1995. Public law: 104-113. March 7, 1996. http://thomas.loc.gov (October 15,1998)

Perry, William. "Defense Science and Technology Strategy Interim Report." May 1996.

Perry, William. "DoD Domestic Technology Transfer/Dual Use Technology Development Technology Transfer," Memorandum, June 2, 1995.

Roessner, David. "What Companies Really Want From the Federal Labs," Issues in Science and Technology, Fall 1993: 37-42. Reprinted in Chemtech, 23, 11 (November 1993): 12-15, and in A. H. Teich, S.D. Nelson, and C. McEnaney, eds., Science and Technology Policy Yearbook, Washington, DC: AAAS, 1994.

Roessner, David and Alden Bean. "Federal Technology Transfer: Industry Interaction with Federal Laboratories," Journal of Technology Transfer, Fall 1990: 5-14.

Semiannual Report to Congress, April 1 to September 30, 1997. US Department of Energy, Office of Inspector General, October 1997.

Stevenson-Wydler Technology Innovation Act of 1980, Public Law: 96-480, October 21, 1980

Technology Transfers: Benefits of Cooperative R&D Agreements, GAO Report, RCED-95-52. Report to the Vice Chairman, Joint Economic Committee, U.S. Congress, December 1994.

Technology Transfer Commercialization Act of 1998. H.R. 2544. July 14, 1998. http://thomas.loc.gov (October 27, 1998)

Technology Transfer in a Time of Transition: A Guide to Defense Conversion. The Federal Laboratory Consortium for Technology Transfer, Washington, DC, August 1995.

"U.S. Commercial and Military Infrared System Markets: Emerging Materials, Price Reductions Offer Excellent Opportunities," Frost and Sullivan, 1995.

Wells, Jim. Technology Transfer, Implementation of CRADAs at NIST, Army, and DOE, GAO Report, T-RCED-93-53. Testimony Before Subcommittee on Energy, Committee on Science, Space, and Technology, House of Representatives, June 10, 1993.

"What is Technology Transfer." *Technology Transfer Resource Guide.* 1996. http://www.nttc.edu/training/guide/seca01.html, (April 8, 1998)

# Acronyms

| | |
|---|---|
| ACR | Advanced Concepts and Requirements |
| AFB | Air Force Base |
| AFRL | U.S. Air Force Research Laboratory |
| AFRL/DE | U.S. Air Force Research Laboratory, Directed Energy Directorate |
| AFRL/HE | U.S. Air Force Research Laboratory, Human Effectiveness Directorate |
| AFRL/ML | U.S. Air Force Research Laboratory, Materials and Manufacturing Directorate |
| AFRL/VS | U.S. Air Force Research Laboratory, Space Vehicles Directorate |
| ARL | U.S. Army Research Laboratory |
| ARTEMIS | Air Force Precision Strike Demonstration Program |
| ASCA | Automated Software for Composite Analysis |
| AUV | Autonomous Underwater Vehicle |
| BETC | Battery Evaluation and Testing Center |
| BST | Barium Strontium Titanate |
| CCD | Charge-Coupled Device |
| CDC | Composites Development Corporation |
| CECOM | U.S. Army Communications and Electronics Command |
| CIT | Center for Innovative Technology |
| COTs | Commercial Off-the-Shelf |
| CRADA | Cooperative Research and Development Agreement |
| CT | Cholera Toxin |
| CT | Computed Tomography |
| CTO | Chief Technical Officer |
| DARPA | Defense Advanced Research Projects Agency |
| DDR&E | Director Defense Research and Engineering |
| DIS | Distributed Interactive Simulation |
| DLA | Defense Logistics Agency |
| DoA | Department of Agriculture |
| DoD | Department of Defense |
| DoE | Department of Energy |
| DoT | Department of Transportation |
| DTAGS | Deep-Towed Acoustic Geophysic System |
| DTT | Domestic Technology Transfer |
| DTTIS | Defense Technology Transfer Information System |

| | |
|---|---|
| DUTD | Dual-Use Technology Development |
| ECR | Electron Cyclotron Etching |
| EPA | Environmental Protection Agency |
| EV/HEV | Electric Vehicle/Hybrid Electric Vehicle |
| FAR | Federal Acquisition Regulations |
| FDA | Food and Drug Administration |
| FLC | Federal Laboratory Consortium |
| FPA | Focal Plane Array |
| FSI | FLIR Systems, Inc. |
| GAO | Government Accounting Office |
| HHS | Health and Human Services |
| HMD | Helmet Mounted Display |
| IFPA | Infrared Focal Plane Array |
| IITSEC | International Service Industry Training Systems and Education Conference |
| IMMS | Integrated Materials Management System |
| IR | Infrared |
| ISBL | Integrated Short Base Line |
| LIRIS | LORAL Infrared Imaging Systems |
| MITE | Megapixel Imaging Technology |
| MSRC | Marine Spill Response Corporation |
| MTPPI | Medical Technology and Practice Patterns Institute, Inc |
| NASA | National Aeronautics and Space Administration |
| NAVSEA | Naval Sea Systems Command |
| NAWC | Naval Air Warfare Center |
| NAWCWPNS | Naval Air Warfare Center Weapons Division |
| NDA | New Drug Application |
| NQR | Nuclear Quadrupole Resonance |
| NRL | Naval Research Laboratory |
| NSWC | Naval Surface Warfare Center |
| NSWCDD | Naval Surface Warfare Center, Carderock Division |
| NUWC | Naval Undersea Warfare Center |
| NUWCDIVNPT | Naval Undersea Warfare Center, Division Newport |
| NVESD | Night Vision and Electronic Sensors Directorate |
| OBP | Ocean Bottom Profiler |
| OO-ALC/TI | Ogden Air Logistics Center, Technology and Industry Support Directorate |
| ORTA | Office of Research and Technology Application |

| | |
|---|---|
| OSD | Office of the Secretary of Defense |
| QC/QA | Quality Control/Quality Assurance |
| PSI | Precision Signal, Inc. |
| POC | Pont of Contact |
| R&D | Research and Development |
| RDA | Research, Development and Acquisition |
| RDT&E | Research, Development, Test and Evaluation |
| S&E | Scientist and Engineer |
| S&T | Science and Technology |
| SBIR | Small Business Innovative Research |
| SGI | Silicon Graphics, Inc. |
| TARDEC | U.S. Army Tank-Automotive Research, Development and Engineering Center |
| TEMO | Training, Exercises, and Military Operations |
| TI | Texas Instruments, Inc. |
| TT | Technology Transfer |
| TTA | Technology Transfer Act of 1986 |
| UV | Ultra Violet |
| WES | U.S. Army Engineers' Waterways Experiment Station |
| WRAIR | Walter Reed Army Institute of Research |
| WSU | Weber State University |

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